The Engineer

APRIL 1, 1955 — 28, ESSEX ST., STRAND, LONDON, W.C.2 — TWO SHILLINGS

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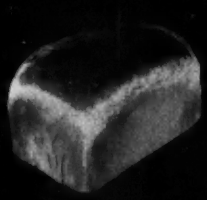
bevel gear unit



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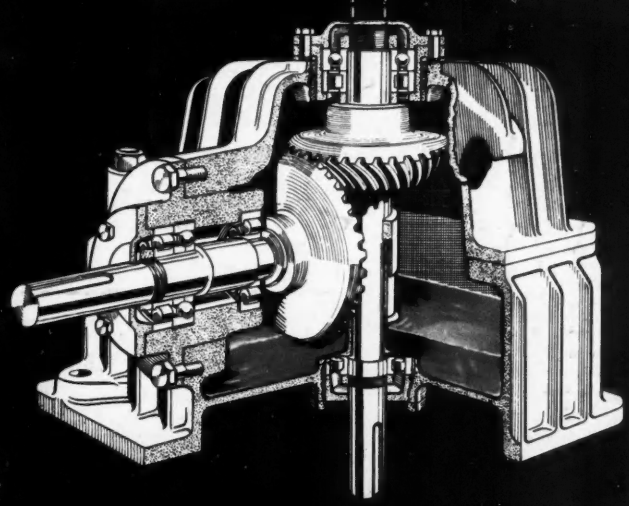

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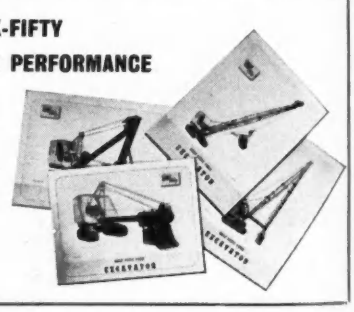

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THE ENGINEER

APRIL 1, 1955

Machine Tool Trades Association

THE annual dinner of the Machine Tool Trades Association was held at Grosvenor House, London, on Wednesday evening of last week, under the chairmanship of the president, Mr. R. D. G. Ryder. After the loyal toasts, the president proposed "The Guests," to which response was made by Viscount Chandos, P.C. In the course of his speech, Lord Chandos said that we were about to enter an even more startling phase in the realm of production, as the increasing use of the electronic control of machine tools was ushering in a new era. Historians of the future, he suggested, would look at this age with amazement. They would think what an extraordinary civilisation it was that invented so many wonderful machines and spent so little time on considering how they should be used. The next speaker was Sir Rowland Smith, who proposed "The Machine Tool Trades Association." He spoke of the development of the machine tool industry and said it was a "far cry" to the days when machine tools were driven solely by steam power through a mass of countershafts, belts and even ropes. To-day, most of our industrial thinking circled around productivity and "automation," a word, Sir Rowland commented, of which he hated the sound! It was, he added, a hybrid word, but it was here to stay and "we had better get to like it." Sir Rowland went on to say that he did not really fear the outcome of "automation." He did not think it would displace a great deal of labour, for history had shown right through that whenever machine tools displaced labour they brought additional blessings which employed labour in other directions. It might well be that certain machine hands would be displaced, but there would be work for them in other directions. The kind of man that would be required for the installation, maintenance and running of the kind of machines envisaged under "automation" would be of a very high standard. The toast was acknowledged on behalf of the Association by Mr. J. B. S. Gabriel, a past-president.

British Summer Train Services

WHEN the summer train services on British Railways start on June 13th next, sixty-four long-distance trains will be accelerated and fifty-eight start-to-stop runs will be made at 60 m.p.h. or more. Amongst the important trains to be accelerated will be "The Flying Scotsman," which will run non-stop between London and Newcastle and will reach Edinburgh in seven hours, and "The Ulster Express," which will leave Heysham at 7 a.m. instead of 6.30 a.m. and arrive at Euston at 11.35 a.m. The 4 p.m. train from Worcester to Oxford is to be extended to Paddington and will be the first train since the war to cover the 63½ miles from Oxford to Paddington in one hour. A novel service is to be introduced for motorists from London and the South. At 7.45 p.m. every Wednesday and Sunday special trains of sleeping cars and motor-car vans only will leave King's Cross for Perth, so that tourists will be saved the 400-mile journey by road from London to the Highlands and will be able to begin a motor-car tour of Scotland the morning after their departure from London. Corresponding return services will leave Perth at 8 p.m. on Tuesdays and Saturdays. Services between Liverpool, Manchester and Birmingham, and between Manchester, Stoke and Birmingham, are to be improved by the introduction of several new trains and by the adjustment of existing schedules. There will be a new train in each direction between the Midlands and Exeter, Torquay and Paignton with connections to and from Cornwall. New cross-country services will be run at week-ends between Blackpool and Perth, Leeds and Edinburgh, Ayr and Manchester and Liverpool, Paignton and Cardiff, Paignton and Wolverhampton, Camborne and Bristol, Sheffield and Bournemouth, and Sheffield and Portsmouth. A new multiple-unit diesel railcar service will be introduced in Lincolnshire as a preliminary to the full diesel scheme planned for next winter, and light-weight diesel units will replace steam trains on the Watford-St. Albans and Harrow-Belmont services.

Institution of Water Engineers

ON Wednesday, March 23rd, the south-eastern section of the Institution of Water Engineers held a meeting at the Institution of Civil Engineers, at which two papers were discussed, namely: "Modifications at Fleam Dyke Pumping Station, Cambridge University and Town Waterworks Company," by W. Grant Gibson, and "Features of Design and Construction of Hornsey Contact Tank for the Metropolitan Water Board," by H. K. Davies and A. W. Turner. The second paper described the problems of building a large contact tank on rather difficult ground, and the soil mechanics studies carried out, and the design based on them present a number of points of technical interest. Owing to the fluctuating loads which would be imposed on clay of variable strength, it was considered advisable to make the structure flexible, so that differential settlement would not give rise to high stresses. A gravel wedge was introduced at the back of the walls to limit the intensity of foundation pressure under the outside edge of the wall, and joints were provided in the walls and floor to ensure that any portion of the structure could settle independently. The work also included the construction of a pump-house in which five 3 m.g.d. vertical-spindle, electrically-driven low lift pumps were installed. A brief account of the first paper presented at the meeting is given on page 461 of this issue.

Sir George Beilby Memorial Awards

THE administrators of the Sir George Beilby memorial fund, who represent the Institute of Metals, the Royal Institute of Chemistry and the Society of Chemical Industry, have made two awards, each of 150 guineas, from the fund for 1954. The recipients are Dr. H. K. Hardy and Dr. J. W. Menter. Dr. Hardy's award is in recognition of his work in physical metallurgy, with special reference to precipitation hardening and to the thermodynamics of phase equilibria in alloy systems. Dr. Hardy joined the physical metallurgy section of the Fulmer Research Institute in 1946, and was subsequently appointed senior metallurgist. Dr. Menter has received his award for his work on surface phenomena, with special reference to the application of electron optical techniques to the elucidation of many different problems. He is a research scientist at the Tube Investments research laboratories, where he leads a group working on surface phenomena. In announcing these awards, the administrators of the fund call attention to the fact that awards are made to British investigators in science as a mark of appreciation of distinguished work, particularly in such fields as fuel economy, chemical engineering and metallurgy, which were Sir George Beilby's special interests. In general, the awards are not applicable to more senior investigators but are granted as an encouragement to relatively young men who have done independent work of exceptional merit over a period of years.

Technical State Scholarships

THE Ministry of Education has sent a memorandum to local education authorities, technical colleges and further education establishments giving details of the technical state scholarships to be awarded this year. This memorandum explains that most of the scholarships will be offered to students from technical colleges and other establishments of further education who have obtained an ordinary national certificate or equivalent qualification, and will enable them to pursue full-time honours degree courses or courses of equivalent standard, at universities, university colleges or establishments for further education. It is stated that candidates must have been in full-time or part-time attendance at a further education establishment for not less than two years immediately preceding August 1st of the year in which the award is made. The Minister of Education may allow an exception to be made to this condition in special circumstances, such as national service. A limited number of awards may also be made to enable suitable candidates, who, by part-time work have obtained an initial qualification of university first degree or higher national certificate standard, to attend approved post-graduate courses of study or research in applied science or technology. The awards will be available for a minimum of one year and a maximum of three years. Candidates for these awards must give full particulars of the study or research which they intend to undertake, and must be recommended not only by the further education establishment at which they obtained their initial qualification, but also by the establishment at which they propose to take a post-graduate course.

Institution of Engineers-in-Charge

LAST Friday evening, the Institution of Engineers held its fiftieth annual dinner at the Holborn Restaurant, London, and also celebrated the sixtieth anniversary of its formation. The Institution, it may be recalled, was founded in 1895 as the Association of Parochial Engineers, its principal aim being to improve the status of those engaged in the maintenance and running of plant installed in poor law institutions. It was soon realised, however, that the Association made a wider appeal, and in 1900, its name was changed to the Association of Engineers-in-Charge. A further change to the present title of Institution of Engineers-in-Charge was made in 1923, the foremost object being declared as the promotion of efficiency in the installation, supervision and maintenance of power plants and machinery of all kinds. At the Jubilee dinner last week, a large company of members and guests assembled under the chairmanship of Mr. R. L. Quertier, the president. A toast to "The Institution" was proposed by Lord Sempill, who recalled some of the Institution's earlier history, and spoke of distinguished presidents and other members who had done much in past years to establish the Institution upon a firm foundation. Lord Sempill went on to describe engineers-in-charge as the men who carried the headaches of industry and kept the wheels turning. It was important, he said, that in these days they should keep themselves abreast of every new development. After a response by the president, the toast "Our Guests and Friends" was felicitously proposed by Sir Willaim Larke, a past-president, who, now approaching his eightieth birthday, quickly revealed that his customary eloquence and vigour as an after-dinner speaker were in no way diminished. Sir William emphasised that we were living in an age of great technological potential, and he emphasised, too, his conviction that this country still led the world in scientific discovery. This toast was acknowledged by Dr. W. A. Macfarlane, director of the National Industrial Fuel Efficiency Service. The final toast of the evening was "Our President." It was graciously proposed by Mr. F. E. Shaw, chairman of the Institution. Throughout the speeches there were many references to the devoted work, over a period of many years, of Captain A. E. Penn, the Institution's indefatigable honorary secretary. Captain Penn joined the Institution in 1902, and was elected honorary secretary ten years later. His zeal and ability in all its affairs have made no small contribution to the value of the Institution's work.

Damodar Valley Project

BY OUR INDIAN CORRESPONDENT

No. I

Considerable interest has been aroused by the progress of the Damodar Valley Corporation's development schemes. The first stage of development is due to be completed in 1957 ; *it involves* 300*MW capacity of electrical power, a million acres of irrigation, and about* 100,000 *acres of land reclamation, and navigational facilities.*

THE Damodar Valley development is the first multi-purpose river development of its kind in India. The valley itself is not very big by Indian standards, nor is the project as a whole comparable to some of the other big ones now under construction in other parts of the country. The power and irrigation benefits are in many ways much less substantial than those, say, accruing under the Hirakud project on the Mahanadi (THE ENGINEER, December 18 and December 25, 1953), or even some of the smaller projects in the south. But the Damodar development is unique in having been conceived on a comprehensive basis with the avowed object of " social and economic rehabilitation of a valley and people gone to seed," as the preliminary memorandum,[4] first prepared about ten years ago, puts it. It is therefore to be emphasised that the technical and engineering aspects of development are of a somewhat secondary importance and are, in fact, of a fairly routine nature. But the plan as a whole and the manner of its implementation and the general approach to social and economic problems which it reflects merit attention, and the project, therefore, has been hailed as something of a national achievement in much the same way as the Aswan dam in Egypt and the Hoover dam in the United States.

The project is based around the flood control problem. " The primary considerations for a plan of development of the Damodar Valley should be the control of floods," the memorandum states at the very beginning of its report. The problem is not of recent origin. The reports published in the records of the Bengal Government[1] reveal the serious concern of that Government with the Damodar flood control problem. The earlier papers refer mainly to the conditions and managements of the embankments which, at the time of the earliest report (January, 1852), were stated to have existed for a century—that is, for over 200 years the people of the valley have been seriously troubled by the floods in the valley. These embankments, which at that time existed on both banks of the lower river, were frequently breached and in 1857 the Government found it impossible to maintain both embankments and decided to relieve the left one by breaching the right for a distance of 20 miles. Flood control by reservoirs was considered as early as 1863 and starting in January, 1864, Lieut. Garnault made a survey of the Damodar River for the purpose of locating storage reservoir sites. A supplementary survey by Lieut. Heywood was undertaken beginning October, 1866. In 1902, Mr. Horn recommended a reservoir on the Barakar River, just above its junction with the Damodar, at the same site, where, eleven years later, Mr. Addams-Williams recommended a larger reservoir for the same purpose. A series of notes between 1918 and 1919 refer to the flood problem and the means to counteract it. The last report on flood control[3] was undertaken after the disastrous flood of July, 1943, in the middle of the second world war. This report recommended the construction of reservoirs with a capacity of not less than 1·5 million acre-feet, and also called attention to the possibilities of multi-purpose development. The report[4] on which the present project is based was published in August, 1945. It is the first comprehensive report of that kind drawn up for the development of an Indian River and because the author concerned, Mr. W. L. Voorduin, was formerly chief projects officer of the Tennessee Valley Authority, the project has been pictured in the people's minds as India's T.V.A.

The Damodar Valley basin is roughly 8500 square miles in area and has a population of about 5,000,000 people. Of this, the urban population is less than 6 per cent and more than half of the total live in about 3000 square miles in the lower reaches of the river. There are about 3,000,000 people outside the valley proper, but close enough to benefit from the development. They include about 2·5 million citizens of Calcutta and other Bengal towns.

Although the people are poor, the valley is probably the richest in the country, abounding in industrial minerals.[6] Over 80 per cent of Indian coal is mined in the valley and so is over 90 per cent of the country's iron ore. The reserves of coal in the valley are estimated at 25,950 million tons, of which about 5000 million tons are supposed to be workable. Iron ore reserves have been put at 8000 million tons and the ore is noted for its high iron content, low sulphur and titanium, and low, though variable, phosphorus. The valley also produces over 70 per cent of the country's mica and is known to have reserves of about 8·5 million tons of bauxite. In addition, it has deposits of most refractory materials with the exception of graphite and magnesite and has large deposits, among others, of clay, apatite, barytes, kyanite (the deposits of Lapsa Baru being the largest in the world), limestone, silica and steatite. Other minerals such as asbestos, chromite, copper, manganese and vanadium are found in sparse quantities, although there are reasons to believe that their extent is much more widespread than can be estimated from the present investigations. Such excellent mineral wealth has led to the valley's industrial development, which includes the steelworks at Jamshedpur and Burnpur (producing between them almost the whole of the country's steel output), fire and silica works at Kumardhubi, paper mills at Raniganj, aluminium and copper smelting plants at Anupnagar and Ghatshila, cement factories at Khalari and round about Jamshedpur, and several important industries

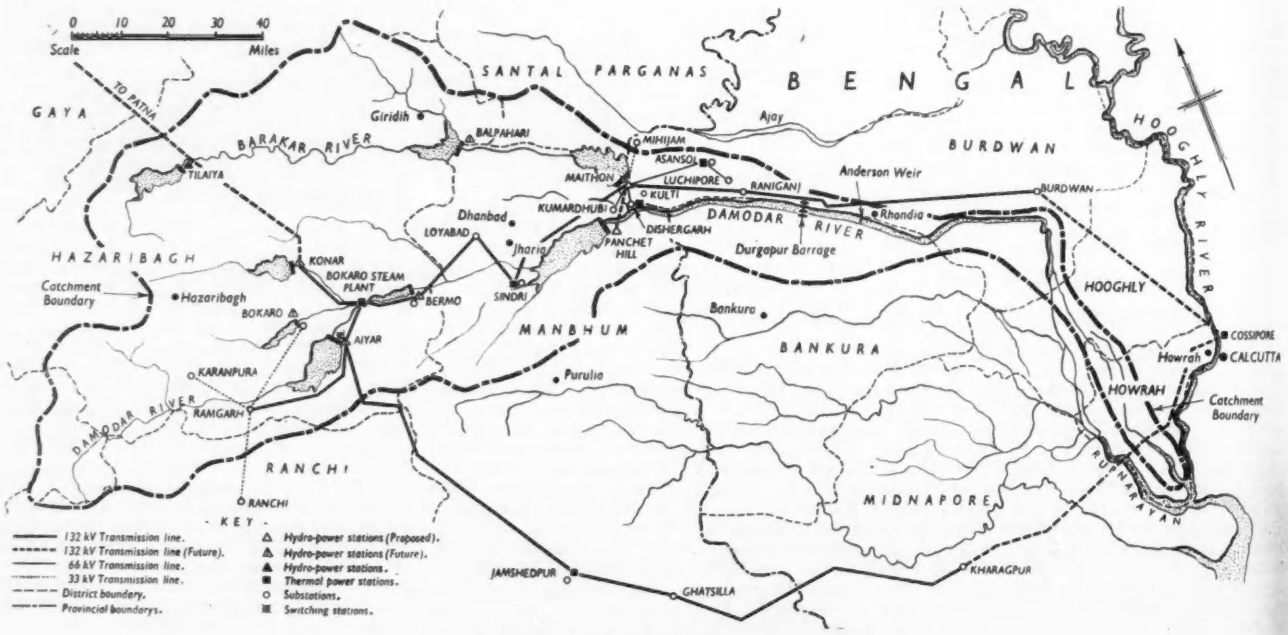


Fig. 1—Map of Damodar Valley showing power transmission grid

along the Hooghly in or near Howrah, e.g. bone mills, cotton mills, jute mills and ship repair works.

The main crop is Aman rice paddy, which is highly dependent on an ample and well-distributed supply of water during the months July–September. The plants usually flower during October and a good supply of water is again needed during the flowering season. The crop is ready for harvesting, generally, in November. Without water during the above periods the crop is a partial or complete failure. Such failures occur on an average about once in three years; for instance, in 1943, when, despite the heavy floods, the monsoon was so distributed that there was not enough water available during the critical sowing and ripening periods.

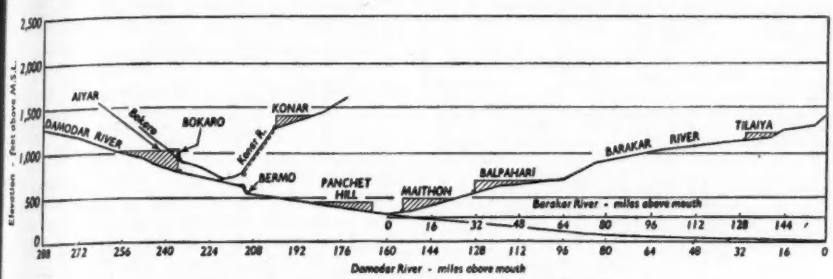


Fig. 2—Profiles of Damodar River and tributaries

The River

The Damodar River rises in Western Bihar in the hills of Chhota Nagpur, and flows generally in a south-easterly direction for a distance of approximately 180 miles through Bihar State and continues on the same general course through West Bengal entering the deltaic plains below Ranigunj. Some distance below this point, in the vicinity of Burdwan, the river abruptly changes its course to a southerly direction and debouches into the Hooghly River, a tributary of River Ganga, some 30 miles below Calcutta. It has eight tributary streams, the principal being Barakar, which enters the Damodar from the north, where it emerges from the hills. The Damodar is 336 miles long; it rises at an elevation of about 2000ft above mean sea level, has a gradient of approximately 10ft per mile for the first 150 miles, 3ft per mile for the next 100, and less than 1ft per mile in the remaining 90 miles. The catchment area of the river (Fig. 1) at its mouth is about 8500 square miles, of which 6960 square miles is the catchment of the upper Damodar just below its confluence with the Barakar. The profile is shown in Fig. 2. The upper portion of the drainage area—that is, almost 80 per cent of the total—is generally denuded of forests or vegetal cover and under the heavy downpours of the monsoon season the land has become badly eroded and cut by deep gullies. The lower portion of the valley with its gradient of less than 1ft per mile has a heavy deposit of aluvial soil and silt due to the frequent overflows during the flood periods. These silt deposits, in turn, block up the natural drainage channels and aggravate the already menacing flood conditions. There is an embankment or bund to protect the lower stretches from the floods, but there are frequent breaches causing inundation of roads and railway lines. The irrigation system is incomplete because no water can be diverted into the existing irrigation canals during the low flow seasons.

Hydrology

The rainfall in the valley averages about 46·5in per annum, varying from a maximum of 64·3in to a minimum of 30·6in per year during the thirty-three-year period, 1912–44. The upper Damodar basin generally receives a comparatively high rainfall. Between 80 to 95 per cent of the average yearly rainfall occurs during the monsoon months from June to October. Monsoon storms form in the Bay of Bengal and generally travel in a north-westerly direction to reach the valley, the storms being most frequent and of greater intensity during the first half of the monsoon season than during the latter half. For instance, in 1930, out of a total rainfall of 52in, 10·5in were due to a single storm before August 15th, and 7in between August 15th and October 15th. The largest early August storm on record so far is that of 1913, which averaged about 11·8in on the catchment area above Ranigunj, and the run-off coefficient for the storm amounted to approximately 70 per cent. Another large storm, in August, 1917, had a total mean rainfall of 9·6in and was responsible for a run-off coefficient of 54 per cent. These concentrated storm precipitations with their very high run-off coefficients have led to general erosion of land in the upper basin, with the consequent accumulation of silt in the lower reaches (Fig. 3).

The extreme fluctuation in discharge is in keeping with the rainfall characteristics of the valley. The mean weekly stream flow (for a catchment area of 7690 square miles) averaged about 11,000 cusecs during the period 1923–34, while the maximum during the same period amounted to 128,300 cusecs, that is, 11·6 times the average, and the minimum was nil. During the monsoon period, that is from June to October, the average discharge worked out at 25,300 cusecs which, during the dry season, that is from November to May, dropped to an average of 1060 cusecs. In 1936, a year of comparatively high rainfall (56·30in), average discharge during the monsoon was 27,400 cusecs, corresponding to a run-off of 20·30in, and during the dry season it was 2970 cusecs, corresponding to a run-off of 3·06in. In 1935, a year of low rainfall of 34·5in (the average for the valley being 46·5in), the average discharge figures for wet and dry seasons were 13,600 cusecs and 321 cusecs, respectively. Fig. 4 shows mean weekly discharge over the years 1934–42. The total average yearly run-off of the river at Rhondia (catchment area 7690 square miles) has been gauged at 8·10 million acre-feet, of which 7·63 million, that is about 94 per cent, occurs during the monsoon months June-October (Fig. 5).

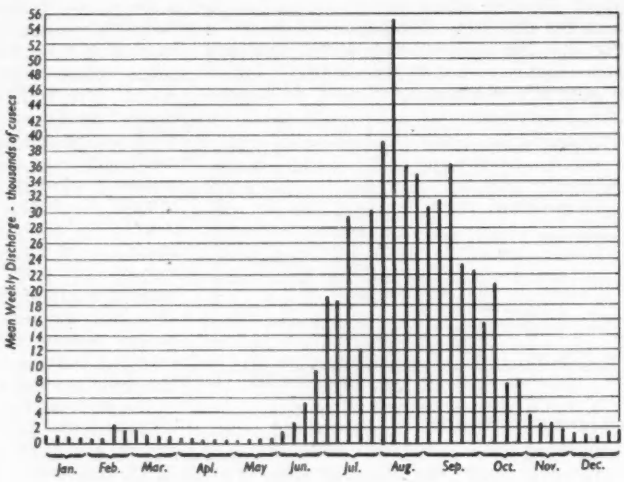
Fig. 3—Soil erosion in the Damodar Valley

Flood Control and Navigation

A peak flow of 650,000 cusecs, that is, roughly sixty times the average discharge, has been recorded twice during the recent years, viz., August, 1913, and August, 1935. The months of July and August register on an average about forty floods in excess of 100,000 cusecs, although no data is available on which to base the size of the maximum design flood. Damodar floods are notorious for the disastrous damage to life and property they leave in their wake and it has been estimated that the total damage since the beginning of this century alone has been at least three to five times the probable outlay on the control reservoirs. The problem of flood control is complicated by the fact that in the lower reaches of the river the land on the right bank could still be flooded by waters from adjoining rivers. Here the river is capable of carrying a maximum flow of only about 50,000 cusecs, while it should have a capacity for at least 250,000 cusecs even after the flood control system is brought into action. The amount of storage capacity required for flood control purposes is computed at about 2·9 million acre-feet of con-

trolled storage and 500,000 acre-feet of uncontrolled storage, to which should be added about 950,000 acre-feet of dead storage.[10]

"A navigation channel," said the preliminary memorandum, "would not be practicable as a separate development, but the regulated flow from the system of reservoirs makes such a development possible. Without this regulated flow, a series of low lift dams and locks would have to be provided in the river, and the cost of such navigation development would be prohibitive." A navigation channel with a sufficient depth for river craft with a draught of about 5ft would relieve the railways of traffic, at present estimated at 200,000 tons per month, mainly coal, and also encourage two-way traffic from the main city of Calcutta to the agricultural hinterland and vice-versa. The channel, if sufficiently wide, would also help in increasing the present flood-carrying capacity of the river five-fold.



Figures indicate mean weekly discharge over the years 1934—1942

Fig. 4—Natural weekly flow at Rhondia

Irrigation and Power

As stated at the outset, the valley is rich in mineral resources and is one of the most highly industrialised regions in the country. Many of these minerals are already being exploited but a serious lack of power has hampered the progress of development. For instance, the Tata Iron and Steelworks at Jamshedpur and the Indian Iron and Steelworks at Burnpur, have plans for expansion of their plant which, until recently, had had to be held over for lack of an adequate supply of power. A detailed load survey of the valley and the adjoining areas was carried out by the Central Technical Power Board in 1946 which indicated the existence of a large and ready market for power. This is rather exceptional for a country like India, where the absence of load constitutes a fairly big initial obstacle in the way of large-scale electrification of the country. The Damodar valley basin is probably the only region in India where the demand for power far exceeds the existing supply. In 1946, there were thirteen power stations above 5MW capacity, totalling 260MW, about 80 per cent of the total capacity. By 1953, the additional demand had risen to another 300MW, of which more than half was taken up by heavy and special industries, such as fertilisers (at Sindri), about 90MW for coalfields, and the rest for town and railway electrification.

Many of the existing power installations are worn out and ready to be scrapped, their gap being filled by power from the D.V.C. grid. But the total amount of hydro-electric power which can ultimately be generated from the whole of the project has been estimated at 232MW, of which about 100MW would be firm and the rest varying in duration on an average from 20 to 80 per cent of the time. This cannot obviously be expected to meet the total demand of over 600MW: hence the necessity of a thermal station to act as a base load during the dry season and as a peak-load station during the wet monsoon season. Mr. Voorduin, therefore, recommended that a thermal power station with an initial capacity of 150MW be built, a recommendation that raised quite a controversy which has not yet died down. In combination with this power station it should be possible, he said, to provide firm power of 300MW at 60 per cent load factor.

Irrigation occupies an important place in the economy of the valley, particularly in the lower deltaic reaches where the soil is rich and fertile. There is an existing canal commanding an area of about 186,000 acres out of a possible 1,000,000 acres, but the canal, for obvious reasons, is not perennial. The total maximum demand for rice cultivation is said to be in the region of 8000 cusecs, with which the reservoirs should be easily able to cope. This represents a useful reservoir storage capacity of 1·5 million acre-feet, including allowance for evaporation.

The Unified Plan

The plan,[4] which closely follows the recommendations of Mr. W. L. Voorduin, has for its primary consideration the control of floods. Other considerations stem almost automatically from this main one. "As far as possible, the system of dams should be capable of producing the largest amount of power which could be made available and maximum use should be made of the regulated supply for irrigation. A navigable channel to the vicinity of the coalfields would also appear to be an attractive feature. Because of the shortage of sources of adequate supplies of drinking water, the plan should include provisions for full use of available water for this purpose. Interference with existing industries should be avoided and provisions must be made to prevent undesirable effects upon the health of the population, such as an increase in the incidence of malaria. Provision must also be included to make the works a permanent improvement rather than a temporary measure."

All this, the D.V.C., the executive authority, is seeking to implement, and the scheme envisages the construction of seven dams, a barrage and a thermal power station, besides a number of smaller works and rehabilitation and general welfare projects. (Fig. 1) The dams are at Tilaiya, Konar, Maithon, Panchet Hill, Aiyar, Balpahari and Bokaro. The thermal station is at Bokaro (The Engineer, February 26, 1954), and a low diversion dam and a power canal will be at Bermo, where the river drops sharply and where a substantial head can be developed for power by utilising a deep gorge and a head of 30ft. The barrage is at Durgapur, about 15 miles downstream of Raniganj, for diversion of water into associated canals and tributaries measuring 1533 miles. The main left-bank canal, 90 miles long, with a number of locks, will serve as a navigation canal. The reservoirs with their storage capacities and other details, are given in Table I. The first stage comprises the first four dams in Table I, of which Tilaiya and Konar are mainly for power and irrigation, and the remaining two for flood control. The ultimate installed hydro-electric capacity will be 232MW and just over a million acres will be brought under irrigation. The four dams, the Bokaro power station, the Durgapur barrage and the ancillary works such as canals and transmission lines, are included in the first stage which is expected to be completed by 1957 or thereabouts. The Tiliaya dam and the Bokaro power station have already been completed and were inaugurated by the Prime Minister, Mr. Jawaharlal Nehru, in February, 1953 (The Engineer, March 20, 1953). The transmission grid including the sub-stations, has advanced sufficiently to enable the D.V.C. to provide power supply to places as far away as Jamshedpur.[9]

The cost of the first stage has been estimated at about £56,000,000 but the figures keep on mounting and the final figure will probably be nearer £75,000,000. The D.V.C. is an autonomous body with powers to borrow money from internal and foreign sources and is responsible to the Government of India, through the Ministry of Irrigation and Power. The Corporation

Table I—*Brief Data on Damodar Valley Corporation Projects*

Dam	On river	Reservoir storage million acre-ft	Height of dam, ft	Ultimate installed capacity, MW	Ultimate units per year million kWH	Date of completion
Tilaiya	Barakar	0·32 (top of gates) 0·26 (live storage)[1]	99	6[2]	22·770	4,000kW commissioned in 1953
Konar	Konar	0·26 (top of gates) 0·21 (live storage)	158	40	191·000	Dam completed June, 1954
Maithon	Barakar	1·104 (top of gates) 0·496 (live storage)	162	60	176·000	1956
Panchet Hill	Damodar	1·214 (top of gates) 0·185 (live storage)	133	40	143·360	1957
Aiyar[3]	Damodar	1·33 (top of gates) 0·731 (live storage)	250	45	Future	
Balpahari[3]	Barakar	0·407 (top of gates) 0·211 (live storage)	115	20	Future	
Bokaro[3]	Bokaro	0·160 (top of gates) 0·08 (live storage)	160	3·2	Future	
Low diversion dam at Bermo[3]	Damodar	Nil	30	18	Future	
Durgapur Barrage[4]	Damodar	Sufficient to balance daily fluctuations	30·5	Nil	—	1956
Bokaro thermal station	The banks of River Konar	—	—	200[5] (4 units)	982·000 with three units	First unit commissioned in 1953

Notes

[1] Live storage means the storage available for release during the dry period for power and irrigation.
[2] Three units of 2MW. Two have been commissioned so far.
[3] Aiyar, Balpahari, Bokaro and Bermo projects are to be included in Stage 2. Their particulars are, therefore, somewhat tentative.
[4] Durgapur Barrage is for irrigation only; in combination with the Maithon and Panchet Hill reservoirs it will irrigate 1,000,000 acres.
[5] Only three units (each 50MW) are to be commissioned in Stage 1. One was commissioned in 1953, and two more are being installed.

receives grants from the Government and has so far received a loan of 38,000,000 dollars from the International Bank of Reconstruction and Development. It is being advised by a board of consultants including Mr. S. O. Harper and, until his death a few months ago, Mr. L. F. Harza. There are also other consultants for individual projects. Most of the work is done departmentally by the Corporation's own staff, which is recruited independently of the Government's recruiting authority and, in fact, in most technical and executive matters, the Corporation is independent of the Central Water and Power Commission, which is

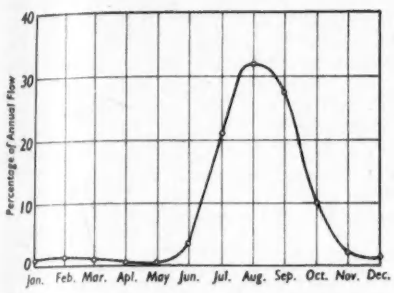


Fig. 5—Average monthly discharge expressed as percentage of mean annual flow (1934-1942)

normally the central planning body for most Indian power projects. Most contractors on the jobs are Indian but many firms have European and American experts to advise them. So far, the D.V.C. has kept to its programme with a few minor exceptions here and there, and it would perhaps be fair to say that the Corporation as a whole has maintained a pace in planning and construction which would have strained many a government organisation. It maintains a good public relations programme and is readily approachable. In India, at least, the initials D.V.C. are now a household word and the opening of a D.V.C. dam or the switching-on of a D.V.C. sub-station is hailed as a major national achievement. No other river valley project in India has been so successful in capturing popular imagination and, what is more, popular sympathy.

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[8] **D.V.C.—Six Years' Progress*, August, 1954.
[9] **Progress Report from the Chairman*, D.V.C., August, 1954.
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* These are official publications issued by the Damodar Valley Corporation, Anderson House, Calcutta-27, India.

(To be continued)

MODERN STREET LIGHTING PRACTICE.—Current practice in street lighting is the subject of a booklet published by the British Thomson-Houston Company, Ltd., Rugby. It outlines the technical approach to street lighting problems, optical design of lanterns and economics, and it includes a chapter on recommendations, specifications and codes of practice.

STEAM TEMPERED TWIST DRILLS.—Samuel Osborn and Co., Ltd., of Sheffield, announces that a new process recently introduced into the manufacture of "Osborn-Mushet" high-speed steel twist drills takes the form of a steam temper, carried out after final grinding and inspection. This steam tempering imparts a distinctive dark blue oxide coating to the drill, and also frees the drill from any stress or strain which may have been set up in final grinding operations. The oxide coating is in the region of 0·0002in thick, and the porous surface is stated to be an excellent retainer of lubricant. This reduces the power required for drilling and keeps the heat generated down to a minimum. With the new finish, there is also said to be less tendency for chips from the material being drilled to weld on to the cutting edge of the drill. In addition to giving a distinctive finish, the oxide coating is impervious to corrosion.

Method of Heating Control

By D. A. SENIOR, M.A., A.M.I.E.E.*

No. II—A MACHINE FOR RAPIDLY PROCESSING PHOTOGRAPHIC RECORDS

(Concluded from page 375, March 18th)

Article No. I described a method of heating a rotating drum and controlling the drum temperature by virtue of the changes in its electrical resistance. This article describes a machine for processing photographic records on paper which utilises such a heating control system. The processer is based on the Kodak hot drum principle. It reaches the operating temperature starting from cold in ninety seconds and enables records taken at 1in per second to be examined a few seconds after exposure and handled dry in less than half a minute

CONSTRUCTION OF THE MACHINE

THE drum consists of a 10in diameter spinning made from a single sheet of copper, 0·060in thick. The spinning is flanged to provide rigidity and silver-plated to give protection against the chemicals used in development. It is mounted on three rollers, two of which are fixed and one spring loaded (see Fig. 5). The rollers are made from "Asp" brand "Tufnol," an insulator which can withstand the operating temperature of the drum. One of the fixed rollers is driven by a small "Singer" sewing machine electric motor through a 100 : 1 worm reduction gear and a 2 : 1 helical gear.

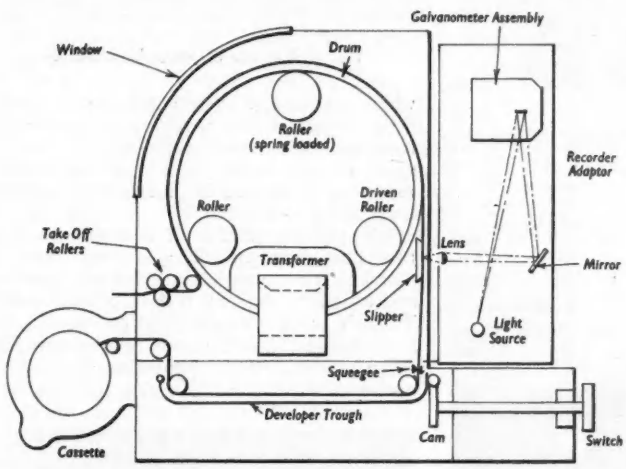

Fig. 5—General layout of machine for rapid processing of photographic records, wet side

The drum forms a short-circuited, single-turn secondary of a transformer and dissipates a power of 500W. The primary winding of the transformer is located inside the drum and carries 608 turns of 19 S.W.G. copper wire, insulated with "Lewbestos," interleaved with "Micanite" glass cloth, and bonded with "Araldite" cement. For convenience in assembly, the iron is in the form of an English Electric Company C-type core (type Z.371017). The core is modified by bevelling the edges of the section which passes through the primary winding as shown dotted in Fig. 5. The winding is thus based on a trapezium instead of the usual rectangular section, so that its outer shape more nearly conforms to that of the drum. In this way a greater diameter of wire can be used in the winding and overheating is avoided. Bevelling of the core does not appear to short circuit the laminations for no local overheating occurs. An alternative would have been to use a larger C-type core, but this would have had to be made specially.

The photographic paper is held in a cassette which clips on the side of the machine and carries an indicator to show how much remains to be used. The paper is threaded as shown in Fig. 5 passing through a trough of developer, past a squeegee, over a locating slipper and on to the drum. The developed record may be examined through a window before drying is complete. It is finally drawn off the drum by the take-off rollers, which are driven through the 100 : 1 worm and 1 : 1 bevel gears. The developer trough is lifted by a cam when recording is to be begin. As the cam is rotated, a rotary switch, mounted on the same spindle, starts the driving motor.

An adaptor, which is demountable, carries the galvanometers and optical system of an A.R.L. recorder,† and is arranged so that the moving spots of light fall on the paper at the point where it passes over the locating slipper. The slipper forms part of the adaptor so that the paper position is maintained accurately in relation to the optical system without the need to align the adaptor exactly to the drum. The galvanometers are screened, by means of a mu-metal and mild steel box, from the alternating magnetic field of the drum.

† The Admiralty Research Laboratory recorder incorporates twelve micro-galvanometer elements of the moving coil type. It was first demonstrated at the Physical Society Exhibition in London in 1950.

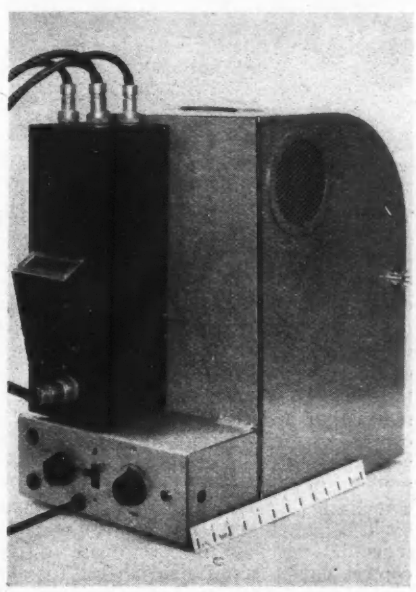

Fig. 6—Photographic processing machine

* Admiralty Research Laboratory, Teddington.

By rotation of a mirror in the adaptor, the spots may be focused either on the recording paper or on a viewing screen (see Fig. 6).

The developer trough, drum and transformer are mounted on one side of a partition within the machine (Fig. 7). The temperature control circuit, the driving motor and gears, and a fan which extracts hot air and steam are situated on the dry side of the partition (Fig. 8). Sample records are shown in Fig. 9 immediately on leaving the machine (upper), and after fixing (lower).

Specification

Paper	Kodak RP.30 is recommended
Paper width	70mm
Paper speed	1in per second
Time to warm up from cold	90 sec
Time interval between recording and examining record	10 sec
Time interval between recording and handling record	30 sec
Paper length	100ft
Developer[1]	Kodak formula H.D.2‡ is recommended
Power required	600W @210V to 250V, 50 c/s)
Dimensions :	
Length	17in
Breadth	11in
Height	18in
Weight	56 lb

‡ H.D.2 formula :

Elon	15 g
Sodium sulphite (anhydrous)	25 g
Trisodium phosphate (hydrate)	40 g
Kodak anti-fog powder	5 g
Teepol	20 ml
Water to	1 litre

Conclusions

The new method of heating and control overcomes the limitations which have hitherto handicapped the hot drum processer.

There is scope for some improvement in the light of experience with the prototype.

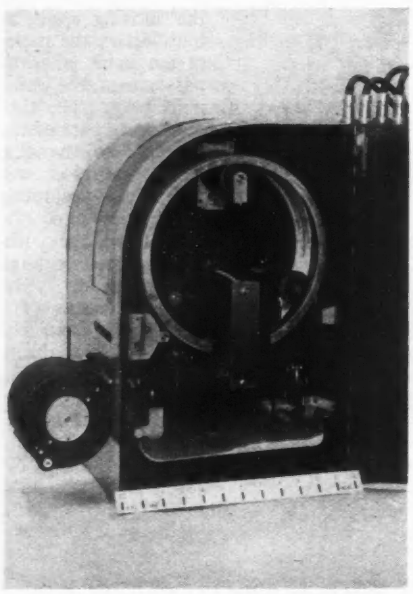

Fig. 7—Wet side of processing machine

The paper speed could probably be raised to 2in per second if desired without increasing the size of the drum. The only modification would be in the size of the transformer, which would be about 10 lb heavier. Alternatively, the present speed could be achieved with a smaller drum, but this would not significantly reduce the size and weight of the machine. The warming up time could be reduced to around twenty seconds at the expense of some increase in weight. There is considerable unoccupied space in the present machine. By rearrangement of components it seems likely that the volume could be halved and the weight considerably reduced. The use of electronics in the control circuit seems unavoidable for the control signal is too small to be used without amplification. A magnetic amplifier version, which can readily be designed, would be of little advantage as it would inevitably be as heavy and as large and no cheaper. Improved speed control would result if an induction motor could be used in place of the present universal motor.

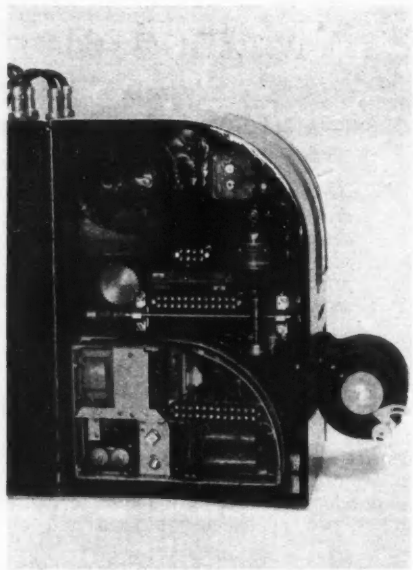

Fig. 8—Dry side of processing machine

These improvements relate largely to the mechanical design. The heating control side has been remarkably free from trouble and can safely be said to have proved itself. There is, in fact, very little to go wrong and it is thought that the new heating control technique will find application on other processes where accurate surface temperature control is important. Examples which come to mind are in the drying of chemicals, foodstuffs and fabrics, in glazing and in the hot rolling of various materials, where the absence of fire risk might be an advantage.

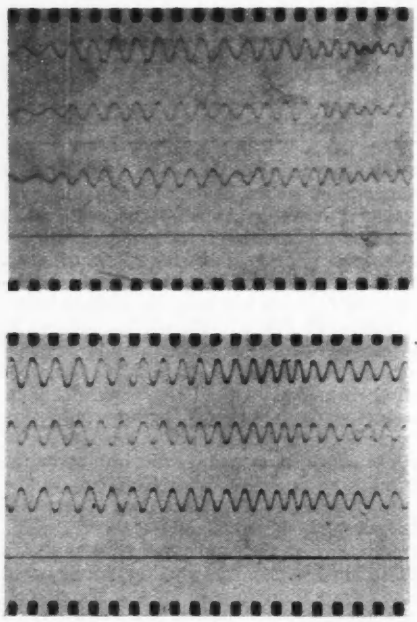

Fig. 9—Record on leaving the processer and after fixing

Acknowledgments

The writer is indebted to Mr. H. H. Margary, of the Admiralty Research Laboratory, who suggested the use of induction heating to generate the heat rapidly where it is required and the use of resistance variation to control the temperature.

It is a pleasure also to acknowledge the work of the A.R.L. drawing-office (particularly Mr. Jager and Mr. Paul), the A.R.L. workshop (Mr. Divey, Mr. Martin and Mr. Peach), and Geometrical Designs, Ltd., (Mr. Norton and Mr. Sharp). Mechanical components were made by Wallace Harvey, Ltd., and electronic construction work was carried out by Winston Electronics, Ltd. The spinning was made by E. J. Purdie and Son, Ltd. The framework of the processer was fabricated by the British Welding Research Association from high-duty aluminium alloy kindly lent at short notice by M.E.X.E. Mr. Halliday, of A.R.L., designed and set up the recorder adaptor also at short notice, whilst Mr. Strong assisted the writer in carrying out final tests and numerous mechanical adjustments. The interest and advice of Dr. Levenson, of Kodak Research Laboratory, are much appreciated. The writer's thanks are due to the Admiralty for permission to publish this article.

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British Standards Institution

All British Standards Specifications can be obtained from the Sales Department of the Institution at 2 Park Street, London, W.1.

SPRING COLLETS

No. 2553 : 1954. Price 5s. Some years ago an investigation disclosed the existence of many thousands of varieties of spring collets for which there was no real technical justification. One result of this large number was that collet manufacturers were compelled to carry heavy stocks of bar thereby sacrificing space otherwise available for manufacture. A committee charged with the preparation of a standard which would either solve or alleviate this situation found that to adopt any one existing make or type of collet for each requirement was really impracticable. Accordingly, with the active co-operation of some machine tool designers, the committee designed a range of collets in nine main types which, while being different in several minor respects from all existing collets, could be produced by all manufacturers with the absolute minimum of dislocation. The only prerequisite to this was that the designs for the machine noses should in future take full account of the dimensions and tolerances of these collets. The results of this co-operation between the main collet manufacturers and the machine tool designers are now presented in this specification.

SIZES OF MANUFACTURERS' TRADE AND TECHNICAL LITERATURE

No. 1311 : 1955. Price 2s. 6d. The standard has been prepared following requests from a number of important trade associations, chiefly in the engineering and building industries, and thirty-eight organisations took an active part in the work ; it is designed to overcome two main difficulties. First, when large plant is installed, one aspect of the contractor's work is simplified if he can furnish full working instructions to his customer by assembling into one binder all the working instruction sheets issued by sub-contractors and suppliers of ancillary equipment. This is often not practicable unless all the literature is of the same size and in any case a heterogeneous collection of sizes presents an untidy appearance that hardly constitutes a good advertisement. Secondly, with catalogues, brochures and pamphlets similar considerations arise. The psychological aspect of this is particularly important for exports because sizes of literature have been standardised in many countries for years. In addition, even if there is no question of grouping with other publications, a great variety of shapes and sizes can become a considerable nuisance to librarians and others who wish to retain literature for reference. Some publishers deliberately produce brochures, &c., in non-standard sizes so that they should stand out from those of their competitors but they may be thrown away because they are inconvenient !

The standard applies to all types of literature issued by manufacturers except "throw-away" publicity leaflets, although there is no reason against applying it also for these. Two sizes are provided and the choice will in practice be governed by requirements ; both have the advantage that they can be cut from stock sizes of almost all the types of paper likely to be used.

Heavy-Duty Truck Development in the U.S.A.

By ROBERT CASS*

No. II—(*Concluded from page 414, March 25th*)

This James Clayton Lecture was read before the Institution of Mechanical Engineers, London, on March 11th. It discussed the principal factors which have influenced the characteristic features of heavy-duty vehicles in America. Sections deal with cab design, engine development, fuel pumps, gas turbines, transmissions, materials and suspension. Parts of these sections have been abstracted herewith.

Diesel Engines

SOME of the reduction in use of diesel engines over the last few years, as evidenced by a drop from 17·5 to 7·6 per cent, is due to the advantages of the large horsepower petrol engines where their lighter weight, together with the decreased weight of the components behind the engine, have such an economic advantage under existing State laws that the petrol engine of the higher horsepowers has reversed the trend to diesel engines to a large degree. As an evidence of the trend in the use of diesel engines, in 1954 domestic sales in the United States dropped approximately 38 per cent below that in 1951. To a larger degree than is perhaps realised, the penetration of the diesel engine into the heavy-duty truck field some

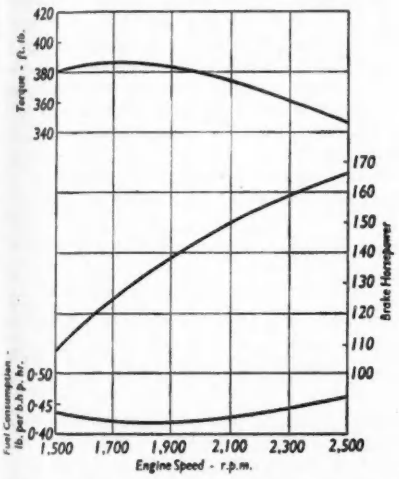

Fig. 7—Horsepower, torque and specific fuel for turbo supercharged diesel engine

years ago started with the need for higher horsepowers than were available at that time in petrol engines, and the resultant economy in fuel cost was certainly no more than of equal importance as against power requirements.

It is interesting to note, at variance with the scene in Europe, that the choice of diesel automotive engines is almost exclusively relegated to three producers, and in the case of engines of 200 h.p. or more to only two manufacturers. All of these engines are of the open chamber type.

The current development of smaller diesel engines is restricted now to no less than 165 h.p. to 170 h.p., and the turbo-charger is, for the first time, making its bid into the trucking scene. The latest engine is 4½in by 5in, has a weight of 1550 lb and an output of 165 h.p. at a speed of 2500 r.p.m. with a minimum specific fuel consumption of 0·420 lb. Fig. 7 shows a detailed performance curve.

A still larger engine is available of the same general turbo-charger design. This is of 5½in bore by 6in stroke, 743 cubic inches, which develops 235 h.p. at a speed of 2100 r.p.m. with a weight with all accessories of approximately 2600 lb. Fig. 8 covers the type of turbo-blower used on these two engines.

Another development which is currently being seriously developed is that of the loop-scavenged engine, and the power range for this V-type of engine is 170 h.p. with a maximum speed of 2600 and a 250 h.p., six-cylinder V-type at the same speed.

In a country where the predominance of petrol engines is so great and the knowledge of the maintenance of diesel engines is still restricted to a relatively small group, the loop-scavenged diesel could very well find favour because of its greater simplicity.

The almost complete use of diesel engines on the railroads, together with a large industrial use of them, precludes any possibility of any marked decrease in diesel fuel prices. Coupled with that, the legislators are inclined to single out diesel fuels for extra taxes and this all adds up to a discouragement of an extended use except in high-mileage operations. This restricted use also has disadvantageous effect on the cost per horsepower, so that the initial investment is a very serious item when considering the use of diesel engines.

The extended use of such engines must await changes other than in fuel economy to make their use attractive in shorter-distance, lighter-weight operations. There is no possibility in the foreseeable future for the use of the small diesel engines used so universally in other countries, and the handling of the refining of petroleum products in the United States market, from both initial price and taxation standpoint, offers very little chance for encouragement on price differential alone.

Diesel Pumps

Early in 1953, at the annual national meeting of the Society of Automotive Engineers, a paper was given covering an entirely new approach to a simplified fuel-injection system. This fuel-injection system is a single-cylinder, opposed-plunger inlet-metering distributor type of pump and was described in great detail at that meeting. It has since been placed on the market for all sizes of diesel engine. It is understood that this pump is currently either about to be manufactured in Great Britain, under licence, or is already available in Britain, so that the design details will not be discussed here. Obviously, material covering the whole pump design will be available through English publications. The price is in the neighbourhood of one-third the cost of pumps commonly used hitherto.

Another company has also just introduced a single-plunger pump and single-delivery valve serving up to and including eight-cylinder engines and in the design has taken into account the features (1) spill metering ; (2) automatic, manual or fixed timing ; (3) flange base or shank mounting ; (4) 100 per cent excess fuel for starting, and (5) adaptability to eight-cylinder engines.

It is reported that this pump will be a subject of manufacture in Great Britain and other countries so that it will be pertinent

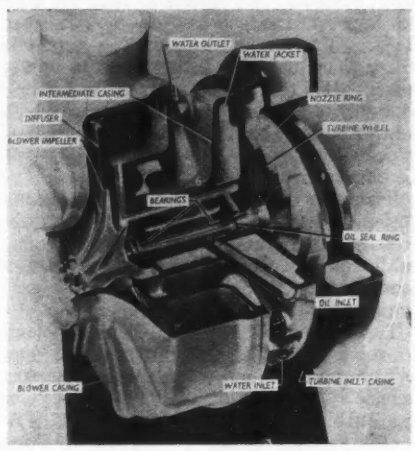

Fig. 8—Cut-away of water- and oil-cooled turbo-supercharger

to discuss still another pump recently introduced, which, however, will be exclusively used on only one manufacturer's engines and which is a combination of redesign of pumps in use over the years in their particular series of engines.

The pump assembly includes, with a weight of only 13 lb, the pump, pressure regulator, governor and the necessary strainers. The pumps it replaced previously weighed 104 lb and 33 lb respectively and the number of parts has been reduced from 448 to 182.

One feature worth noting for hilly operation concerns overrunning the governor going downhill. When this happens all fuel to both idling and high-speed ports is cut off, thus allowing the engine to produce the maximum braking effect.

From the foregoing it is evident that with the three types of diesel pump now currently in use in the United States, the long delayed and much needed changes have been made in the fuel-distributing systems of the automotive diesel engine. It is a low-pressure unit as the high injection pressure is brought about by a special nozzle.

Gas Turbines

The state of development of the gas turbine for automotive vehicles in the United States is reaching an interesting stage and no paper dealing with trends can ignore it. The testing which has been carried out so far on the road involves one truck and one bus (Fig. 9), and the horsepower range has been from 175 to 350. It now seems that 300 h.p. is about the minimum size contemplated for commercial vehicles with a 400 h.p. job derated to around 350. In one turbine the designed speed for the power turbine was 12,000 r.p.m. ; in the other turbine speeds up to 20,000 r.p.m. were used in the original concept. Gas temperatures are held around 1500 deg. in the gasifier turbine.

So far the best specific fuel consumption that has appeared on the scene is in the derated engine which, under best conditions, shows 0·7 lb per brake horsepower. It is felt that with a reduction in internal pressure losses, with a foreseeable rise in operating temperatures and

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use of the regenerator or heat exchanger, in the next few years big strides may be made towards improving the economy. So far it seems possible to use anything in the way of fuel from clean petrol to diesel fuel, with an air/fuel ratio varying from 50 : 1 to 100 : 1.

In regard to actual road performance, the torque curve is ideal for excellent operating characteristics, but work still must be done to improve the acceleration at the start. This is a matter of reduction in weight in the gasifier turbine, which seems not impossible at this time. Performance is definitely smooth, and in operations where torque converters have been and are being considered a necessity they can be eliminated. This will be particularly true of city-type buses.

The noise does not seem to be too difficult to handle as it consists mainly in being able to handle the inlet air. In regard to mechanical stability, from experience to date it seems that such engines can be made as safe in operation as contemporary engines.

Perhaps one of the most difficult problems to solve against the overall need for simplicity and minimum weight of the complete vehicle is the question of braking forces, as gas turbines are free-wheeling units. At present a shorter life of existing braking systems must be faced if added weight cannot be a factor in the design. At the moment there is a fairly wide variation in the weight per horsepower in the two engines mentioned, but with improvement in efficiency it is hoped it can be well within 2 lb per horsepower.

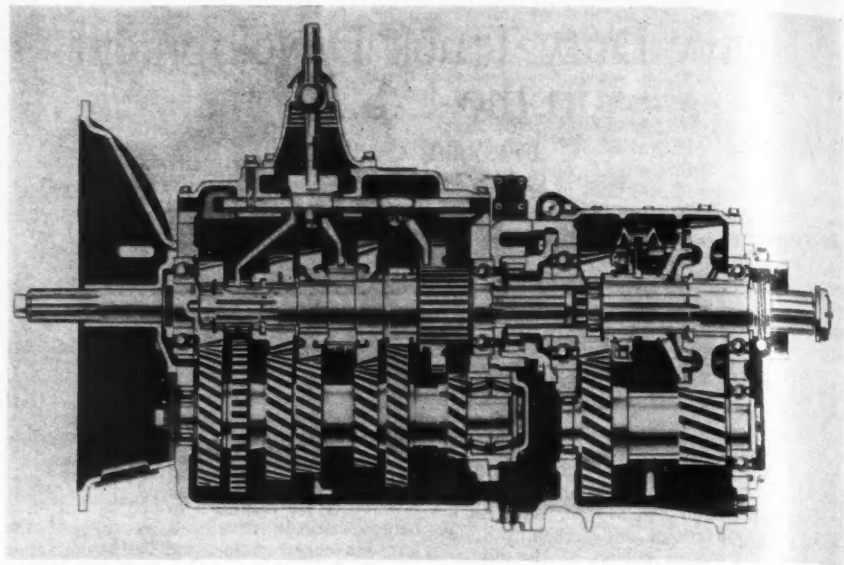
It can be stated that whilst this projected work on the gas turbine is serious in regard to the automotive scene, it is still a long way from being considered as an alternate power plant for existing engines. The reason for such research can be based largely on these facts, which were previously mentioned :—

Most important—its weight per horsepower, that is, 2 lb per horsepower as against 6 lb per horsepower for the lightest weight petrol engine. The gasifier and separate power wheel-type of engine as shown has admirable torque characteristics for heavy-duty truck operation—a very important factor.

Cold starting—in countries such as the United States and Canada where temperatures may be 50 deg. Fah. below zero, the question of starting has long been a very serious matter and the damage done during warm-up can be considerable from a life standpoint. The easy starting characteristics under such conditions and the absence of the need of warm-up make a very attractive picture from an operator's standpoint.

A further point in its favour is its size, as it is felt that it can be adapted quite readily into future space requirements.

The disadvantages of noise, fuel consumption, life, &c., are the retarding factors in its development, quite apart from the cost per horsepower, but the whole matter of automotive gas turbines is being much discussed and particularly so when its use in aircraft in Great Britain and elsewhere has become an everyday matter.



Shifting between ranges by air operation.

Fig. 11—Ten-speed two-range transmission

Transmissions

The basic single transmission which has been used most extensively is made in two versions—the five-speed fifth direct, and five-speed overdrive. These transmissions are either constant mesh or synchromesh with the exception of the starting and reverse gears.

In the medium heavy-duty range 55,000 lb average G.V.W., the two-speed axle with electrically or air-operated change mechanism has taken a firm hold of the market, used in conjunction with a five-speed box.

The interposition of a planetary auxiliary gearbox between the engine and the main transmission has not been developed as it has been in Great Britain—the two-speed axle being much cheaper than such a device in the United States.

To make possible the meeting of the different engine speed characteristics, as well as the very widely differing terrain, auxiliary transmissions were brought out in three-speed and four-speed versions, and the ratios of these transmissions are shown in Table I.

Table I—*Transmission Ratios*

Speed...	3	3	4	3	3
Gear ratio :					
Overdrive	0·86	0·86	0·86 (4th)	0·75	0·84
Direct	1·00	1·00	1·00 (3rd)	1·00	1·00
Underdrive	2·14	1·24	1·24 (2nd)	2·59	1·29
			2·14 (1st)		
Oil capacity, pints ...	8	8	8	12	12
Weight (with oil), pounds	242	242	247	448	448

These are usually located in the middle whilst the main transmission, as is common practice, is unit-mounted with the engine.

The successful application of this trans-

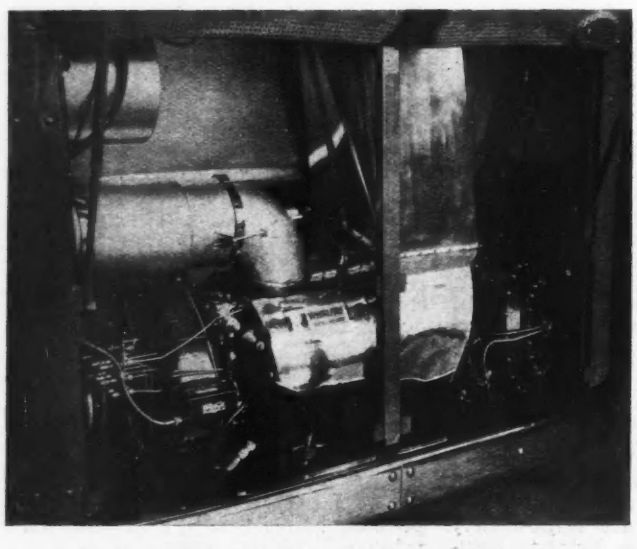


Fig. 9—"Whirlfire" engine installed at rear of test bus

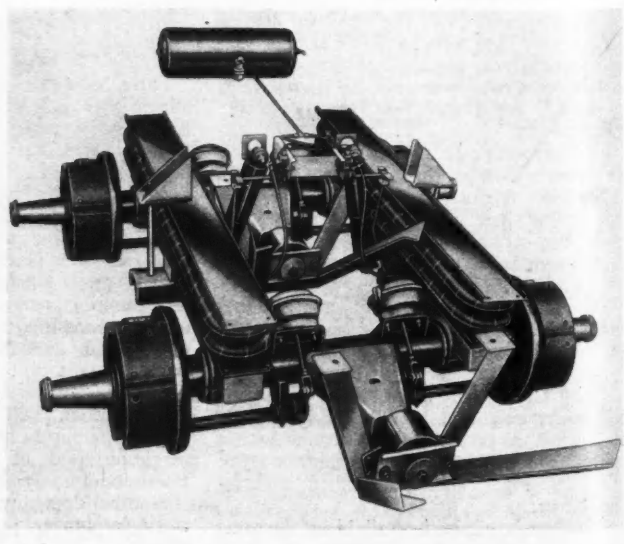


Fig. 10—Air spring design for tandem axles

mission train depends wholly and solely upon the driver as to how successful he will be in meeting the schedule times of his run or what will be the life of the gear sets. It involves manipulating two sets of levers in synchronism with a double-clutching operation and, actually, calls for the driver to remove his hands momentarily from the steering wheel. As unsafe as this practice may seem, it has been common practice in the western States for many years.

This arrangement helped considerably to bridge the wide differences between the characteristics of the diesel and petrol engines so far as speed range was concerned, but it has been costly both in money and in weight and, ultimately, designs were formulated with an idea of meeting this with a compact, single-lever transmission and one which an ordinary driver, instead of a contortionist, could operate.

Fig. 11 shows a ten-speed design which meets these specifications. The eight-speed version is capable of absorbing 430 lb-ft torque and the ten-speed 600 lb-ft torque.

The ratios which are given in Table I are designed for fairly uniform shifting so that speed differences in the engine would be very slight. This even spacing has a distinct advantage to the average driver as he can make his shifts very readily by watching his tachometer. The air-speed change-over from one range to another is again a very simple operative device, and there are at the present time many thousands of these transmissions in active operation. The one big advantage of this type of transmission is that a comparatively inexperienced driver can be taught to handle the gearbox in a relatively short time, and at least ten speeds are essential for the heavy loads carried in most of the territories. Table II gives the main transmissions.

The next significant development is that of a new transmission arrangement, in which a torque converter and two automatically-operated hydraulic clutches are combined as a unit with a five-speed synchromesh transmission. The claimed advantages for this type of transmission deserve very serious consideration as it is simpler than the automatic type of transmission and still has controlled features that many operators think desirable. The obvious advantage is that this five-speed transmission can cover the range of the previously mentioned ten-speed mechanical box with weight and length advantages and the flexibility which the driver has is such that the number of changes necessary to make, under certain conditions, can be reduced by two-thirds, which is obviously a very important point in operation in congested areas. Furthermore, reduction in shock loading of the transmission parts, universal joints and rear-axle parts are features of this design.

Fig. 12 shows the range of the converter in any ratio, and in Fig. 13 will be seen how additional braking when drifting is added to that of the engine braking, and in the lower gears the amount is considerable.

One of the principal problems of operation in congested areas is the short life of the manually-operated friction clutch. This semi-automatic type eliminates the necessity for the manually-operated clutch, and tests to date indicate that the fuel mileage in average operation is low.

Materials

Aluminium, in the United States, has always been expensive for the weight reduction made possible by its use and, until recently, the high-strength alloys—except in engine pistons—have attracted very little attention. The methods of fabrication as well as lack of knowledge of fatigue life have also retarded its use. In the western area of the country, where the lowest possible tare weight was early considered of the greatest importance and truck production was small, aluminium has been used for many parts such as cab, hood, wheel hubs, spring hangers, steering gears, engine and transmission mountings, miscellaneous levers, &c. In fact, in those areas of low production, rather extensive use of aluminium was occurring before the 1939–45 war, but immediately war broke out all use of aluminium was discontinued.

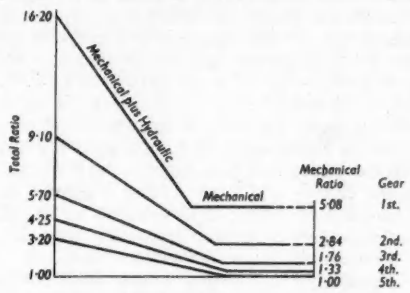


Fig. 12—Typical synchronous converter ratios

Since that war these rather specially designed chassis have reverted to aluminium, but more as optional than as standard equipment when applied to frame rails, cross members and gusset plates. This is also true of axle housings and transmission cases which are offered as optional items; but high-production methods of cabs and other sheet metal parts—which call for pressure welding fabrication—have not been solved for aluminium alloy sheets, although hand welding is employed in cab manufacture in limited production.

It may be of interest to give some figures on practical weight saving already achieved. In the case of wheel hubs it varies from 50 lb to 55 lb reduction in weight, and the main frame rails are approximately two-thirds the weight of steel rails. Frames, cross members are credited with a 60 per cent reduction over steel and, in general, aluminium castings are figured as saving 50 per cent.

The present thinking in regard to aluminium is that it has disadvantages where the part must be designed for stiffness or rigidity, such as rear-axle housings or where the aluminium part is subject to abrasive action of harder material. In general, aluminium occupies a relatively small place to-day in the overall heavy-duty truck design picture.

In regard to plastics, there is some interest being shown in the use of fibre glass and similar plastics in parts such as fenders (mud guards), and it is significant that except for possible weight saving production-wise, no advantage can be found in the price after an output of 20,000–30,000 parts is involved. At that stage, it is estimated that steel parts can be produced at a lower price.

Generally speaking, except for the use of synthetic material in upholstery and small non-operating parts it is expected that comparatively little will be done with plastics for several years.

Nickel continues to be a problem owing to stockpiling for military purposes.

Power Steering.—The number of heavy-duty trucks equipped with power steering is still quite small, but it is only a matter of time before it will be on a large percentage of factory output.

Air Springing

The idea of air springing dates back to the early 1900s, and from then until now sporadic attempts have been made to develop a saleable system for the truck, truck-trailer, and bus field.

Two large tyre manufacturers, sponsoring different applications, have now made available to the manufacturers properly developed arrangements and parts. Buses as well as many truck trailers are running to-day and the designs are being actively considered for trucks. The ride in buses, for instance, is admirable and there is no reason why similar good characteristics cannot be worked out for any motor vehicle, including trucks.

Perhaps the two systems can be described as the "bag" type and the "bottle" type.

TABLE II—*Main Transmissions*

Speed ... Helical gears	8 All forward speeds				10 All forward speeds			
Gear ratios...	High range		Low range		High range		Low range	
	Gear	Ratio	Gear	Ratio	Gear	Ratio	Gear	Ratio
	8	1·00	4	3·68	10	1·00	5	3·55
	7	1·36	3	4·99	9	1·27	4	4·49
	6	1·90	2	6·98	8	1·64	3	5·82
	5	2·66	1	9·78	7	2·10	2	7·45
					6	2·73	1	9·70
Reverse ratios	2·99		11·01		3·52		12·50	

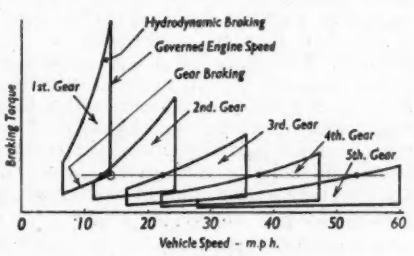


Fig. 13—Braking torques

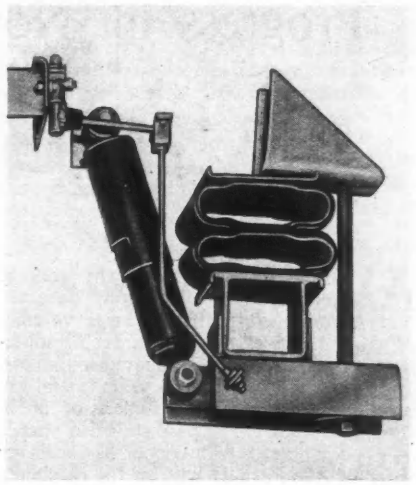


Fig. 14—Cross section of air spring in Fig. 10

The most important feature of each design is the levelling valve, which, in conjunction with some form of sway control, makes the whole idea workable. Similarly, the development of nylon bushings has increased the life potential of the bearings necessary for low maintenance.

The air source comes from the compressor originally mounted on the engine for the air braking system of the vehicles and, therefore, the availability of energy simply calls for an additional reservoir, entirely separate from the braking system, and a larger output compressor.

In passing it should be noted that the air compressor is now being called upon to do much more work. To the air brake duty can now be added this type of springing as well as air power steering. The largest automotive compressor in use is now 12 c.f.m.

Without attempting, at this stage, to analyse the ultimate cost and weight—it is sufficient to say that they are fairly favourable and the capacity for successful absorption of torque is evidenced by the use behind a 220 h.p. diesel engine and the successful braking of a tandem-axle operating at a speed of 60 m.p.h., with a weight on the tyres of 16 short tons. Obviously, there is additional cost involved in the use of this type of suspension, but the consideration at this time leads to the conclusion that more and more vehicles will be so equipped in the heavy-duty field in the next few years.

Off-the-Highway Vehicles

No review of the heavy-duty truck picture would be complete without some brief mention of off-the-highway vehicles.

Generally speaking, we have two categories —the first being basic highway vehicles with some additional features built in for strength. The second group of off-the-highway units, which are the real heavy-duty vehicles, never get on the highway and are divided roughly as follows :—4×2 up to 100,000 lb G.V.W. and 6×4 and 6×6 up to 250,000 lb. Typical of the latter figure is a group of vehicles built for a copper mining company with two eight-cylinder 350 h.p. engines, with a combined chassis and body weight of 90,000 lb. This kind of vehicle is so complex as to call for extremely different engineering approach than is usually found in truck manufacture.

Planetary gear axles predominate with combined centre and wheel ratios of around 17/1 to 20/1, and torque converters are indispensable.

Progress in Non-Ferrous Metals

By DR. MAURICE COOK

No. I

Here are reprinted extracts from the Presidential Address delivered by the author before the Institute of Metals last Wednesday, March 30th. Dr. Cook surveyed broadly the progress in non-ferrous metallurgy between the termination of the first world war and the present day, dealing particularly, but not exclusively, with wrought non-ferrous metals and alloys.

Casting

As long as forty years ago, the work of Sieverts and his collaborators indicated that molten metals dissolve large volumes of gases, the release of which during solidification might account for ingot unsoundness, and over the last thirty years metal-gas reactions have been the subject of much successful research. Conspicuous in studies of gas equilibrium with copper has been the work of Allen and Hewitt on the combined effect of oxygen and hydrogen, and of Floe and Chipman on the role of sulphur. Gases in alloys, and their removal, have been the subject of investigations for many years by the British Non-Ferrous Metals Research Association, and these have shown that in alloys not containing dissolved oxygen, and therefore not subject to the steam reaction, solution and subsequent emission of hydrogen is the major source of unsoundness, the remedies being suitable precautions in melting, removal of gas by pre-solidification, or treatment with a non-soluble gas, such as nitrogen. In 1925, Portevin showed that additions of an oxidising agent could eliminate unsoundness in gun metal, and Lepp later proposed the use of oxidising slags as a means of controlling dissolved gases in copper alloys generally. That hydrogen was a cause of unsoundness in aluminium alloy castings was recognised in 1929 by Claus, who showed that it originated from the decomposition of water by molten aluminium. This was confirmed in 1931 by Hanson and Slater, who, amongst others, demonstrated the efficacy of treatments with chlorine or nitrogen for removal of hydrogen, procedures which have since become normal industrial practice. Realisation of the ill-effects of gases led to the accelerated adoption of electric melting, utilising arc, resistance, high- and low-frequency induction furnaces, and some of these have now almost entirely replaced other forms of melting in many sections of the industry.

The use of continuous casting is another outstanding innovation, and the method originated by Junghans, some twenty-five years ago, has been successfully applied in the casting of brass alloys, and more recently for copper. The increase in demand for aluminium alloys in recent years focused attention on the need for better casting techniques. The production of sound ingots depends, amongst other things, on non-turbulent filling of the mould, and for many alloys rapid chilling is needed to obtain the necessary fine dispersal of phases. Following the lead of Junghan's work on the continuous casting of brass, in 1936 German investigations showed that by using a short mould and effecting most of the cooling by the direct application of water to the solidified ingot skin, a greater degree of chilling could be obtained than by conventional casting methods. Processes of this type, known as semi-continuous, proved to be so successful in yielding good quality products that they were rapidly developed, and in less than ten years became standard practice in the wrought aluminium industry throughout the world, and now they are beginning to be used for the casting of copper and copper alloys.

Rolling

From slow, simple, ponderously driven machines, rolling mills have been transformed over a span of relatively few years into highly mechanised precision units capable of rolling heavy weights of metal accurately at high speeds. In general, it can be said that the rolling of long lengths of coil in wide widths reflects the chief difference in strip and sheet rolling practice to-day compared with that of thirty years ago, when narrow coils of small weight were produced by slow-speed rolling on two-high mills.

The early forms of two-high mills were greatly improved by the incorporation of such features as machine-cut gears, totally enclosed pinions revolving in oil, better bearings and lubrication, and mechanical adjustments for rolls, together with an overall greater accuracy in construction. These, and many more subsequent refinements, have contributed to the evolution of the efficient two-high mill as we know it to-day. It is, however, the four-high mill that has marked the greatest change in rolling installations. Although the concept of such a mill is not new, indeed it was thought of by Leonardo da Vinci as far back as 1486, it was the need for suitable equipment for rolling strip many times wider than was the general practice thirty years ago that gave rise to the four-high mill. Mills of this type were first used in the U.S.A. where, in 1926, a four stand tandem mill was erected for cold rolling 36in wide copper strip. A few years later, four-high mills were erected in this country, and since then they have come into more general use, and for the hot and cold rolling of aluminium and its alloys in widths of up to 100in, mass production methods have been adopted to an increasing extent on lines similar to those used in modern continuous steel plants.

Other types of multi-high mills have more recently made their appearance such as the Steckel mill, in which all the energy of rolling is transmitted by the coiler and decoiler, and the Sendzimir mill, with working rolls as small as ¼in in diameter, which not only reduces power requirements, but facilitates rolling of strip in wide widths to thin gauges, particularly in harder alloys. For hot rolling, a recent and novel plant is the planetary mill, which would appear to have considerable possibilities. On this mill, reduction is effected by means of small diameter rolls symmetrically disposed around the circumference of the rolls of a two-high mill, and it is possible to obtain, in one pass, a greater reduction than can be achieved in ten or more passes on conventional hot rolling mills.

Tube Manufacture

Whilst some of the improvements effected in tube manufacture during the last twenty-five years relate to the production of tube shells, the most radical changes have been in drawing operations. Drawing on mandrels in short lengths, that is, about 20-30ft, at speeds rarely exceeding 100ft per minute, on single hole benches, was the method generally employed for many years, and the first major change began to take place in the early 1930s, with the introduction of fixed plug drawing, which made possible the processing of longer lengths at higher speeds and, moreover, the drawing of several tubes simultaneously. The years immediately following saw the further development of this method and also of the floating plug technique, as well as multiple drawing, so that towards the end of the 1930s fully automatic triple draw benches began to appear in the tube mills of this country, followed more recently by highly mechanised triple draw benches with capacities up to 300,000 lb pull, and able to draw tubes up to 150ft long, at speeds of about 350ft per minute.

The work on plug design which made it possible to dispense with the plug rod and allow the plug to float, opened the way for block drawing, in which tubing, reduced by conventional methods to 2in diameter or less, is further drawn on bull blocks, coiled after each draw and left either in long coils or alternatively straightened and cut to required lengths. This method has made possible

the production of tubing in much greater lengths than could formerly be manufactured by other drawing techniques and at drawing speeds of up to 1800ft per minute.

Another departure from conventional bench drawing, particularly suitable for processing relatively hard alloys, is tube reducing which was introduced about 1930.

Condenser Tubes

Ever since sea-going vessels have been fitted with condensers as part of their power-raising equipment, copper alloys have been used for condenser tubes. For many long decades 70/30 brass was the alloy generally employed both for this purpose and also in condensers for land power stations. As far back as 1890, Admiralty brass, essentially the same alloy, with the addition of 1 per cent of tin, was in use as a superior product for more onerous service conditions. As these progressively increased in severity, the problems, and the consequences, of condenser tube corrosion became not only serious, but in some circumstances critical and grave. In 1910 the Council of this Institute established a Corrosion Committee and inaugurated research on the subject of corrosion, especially of corrosion problems associated with condenser systems, and this work has continued up to the present day, that is, over a period of forty-five years, a long time by any reckoning for a sustained research effort in one fairly narrow field. In that time the subject, which is most complex, has been studied from many angles. Much has been learned of the nature of corrosion processes, innumerable laboratory experiments and field trials have been carried out, the causes of many corrosion troubles that once were chronic have been tracked down, novel and valuable testing procedures have been devised and greatly improved, and far more serviceable materials have been developed and are now being produced. The first report to the Corrosion Committee of the Institute was published in 1911, in Volume 5 of the *Journal*, and the eighth and last in Volume 49, in 1928. With these reports and the investigations they describe, the name of Bengough is particularly associated. In 1930 the responsibility for the work was transferred to the British Non-Ferrous Metals Research Association, and under its ægis has continued with unabated vigour and conspicuous success. At the same time, industrial concerns pursued their investigations and developments in the same field. It can, I think, be fairly claimed that the work done in this country has been mainly responsible for solving the major problems of condenser tube corrosion, and for the development of corrosion resistant alloys which have since become so widely used throughout the world.

Condenser tubes of 80/20 cupro-nickel were first made in 1921 in this country. In 1925 this alloy was superseded by 70/30 cupro-nickel, which was shown to be markedly superior, and tubes of this latter alloy, after approval by the Admiralty, were adopted in 1927 as standard for the Royal Navy and formed the subject of a specification in 1930. Investigations which stemmed from variability of performance of tubes in service showed that relatively small amounts of iron and manganese, especially the former, greatly improved the resistance of the alloy to corrosion, and particularly to impingement attack. In consequence, the specification was modified in 1934 to include iron plus manganese, and later changes cover up to 1·0 per cent iron and 1·3 per cent manganese. This is the type of cupro-nickel that has been developed after years of experiment and experience, and is now generally fitted in the condensers of naval vessels and large ocean-going liners, and used in many land power stations where the condensing systems have to contend with severe corrosive conditions.

At one time it was thought that aluminium in brass impaired the corrosion resistance of the alloy, but work done in the early 1920s at Woolwich for the British Non-Ferrous Metals Research Association and later in the Association's laboratories showed, on the contrary, that it was indeed most beneficial, and thereafter a brass of the alpha type, containing about 2 per cent aluminium, was developed as a condenser tube material. It would seem to have been first so employed in about 1929, and since then its use in this and other applications has continued to increase. The presence of this amount of aluminium also greatly improves the resistance of brass to oxidation at elevated temperatures, for at 775 deg. C., for example, the rate of oxidation is only about one-fortieth that of a straight brass.

Copper

The use of copper alloys extends over thousands of years and their production has featured in the industrial development of this country for centuries. Despite this long history, nothing was heard of heat-treatable copper alloys until about the middle of the 1920s. About that time, the investigations of Corson, Masing, Fraenkel and others revealed that several copper alloys could be hardened by heat-treatment alone. The outstanding example was the copper-beryllium alloys which, with other alloying additions, were studied in considerable detail and have since been developed more than any other heat-treatable copper alloys. Since then, the number of age-hardenable copper-base alloys which have been found runs into hundreds. Many of these have not been studied in any detail but a few, notably those containing nickel with additions of silicon, aluminium, manganese, tin or phosphorus, and those containing chromium, have been used industrially to some extent, and papers dealing with some of these have appeared in the *Journal* of this Institute. As Merica said more than twenty years ago in speaking of alloys which are hardenable by heat-treatment alone, such alloys may be the rule rather than the exception amongst alloying systems. Although there are many uses for some of these alloys, the total amount produced is triflingly small in relation to other copper alloys, and thus their relative importance is very different from that of the heat-treatable alloys in the aluminium industry. There, the discovery of age-hardenable alloys opened up a wide vista of possibilities for aluminium, when that metal was still in its infancy, and the development of alloys of this type contributed greatly to the growth of the light metals industry and are to-day an important part of its production. For the purposes for which many of the more familiar copper alloys are, and have been, generally used, their physical and mechanical properties are suitable and adequate and the discovery of heat-treatable alloys went unheralded and made no perceptible industrial impact. However, whilst such special uses as there are for those heat-treatable copper alloys available in wrought forms, do not at present involve the consumption of more than modest tonnages, the ever-increasing volume and variety of new developments in many fields suggest that this situation is one which could rapidly and appreciably change. Knowledge of most of these alloys extends little beyond an approximate determination of their constitution and only for a few alloys is any detailed information about physical properties available. Many of the alloys are difficult to produce and some require prolonged thermal treatments for optimum properties to be obtained. The known alloys of this type, as well as those not so well known, would seem to merit further investigation, of both a fundamental and technological kind, since some of them have interesting properties about which more could, with advantage, be learned. Moreover, for the further development of these materials more information is needed about the nature of the hardening processes that take place, as well as many other aspects of them, including the possibility of drastically shortening the prolonged thermal treatments necessary with some of these alloys to obtain optimum properties.

Aluminium

The purity of aluminium made by the reduction of alumina normally ranges from about 99 per cent to 99·8 per cent and whilst most of the current output consists of qualities in that range of composition, high-purity aluminium is becoming more and more important. This grade with a purity of upwards of 99·99 per cent, is produced by a second electrolytic process involving the three-layer refining cell, and its manufacture on an industrial scale, which started about the mid-thirties, is one of the most important new features in aluminium production since Hall and Heroult introduced their reduction process in 1886. Valuable attributes such as increased corrosion resistance, workability and thermal and electrical conductivity, as well as excellent anodising properties and high reflectivity, understandably account for the increasing use of this quality of aluminium and, moreover, its use in making certain alloys is growing and would seem likely to continue.

Most of the types of aluminium alloy now in use have been known for a long time, but over the years many modified versions with better properties have been developed from their predecessors. Thus, although there seems to be a large number of compositions in use, the principal alloys all fall essentially into six groups, i.e. the three non-heat-treatable series, aluminium-manganese, aluminium-magnesium and aluminium-silicon, and three heat-treatable types based on the aluminium-copper-magnesium-silicon, aluminium-zinc-magnesium, and aluminium-silicon magnesium systems. The strongest of the heat-treatable alloys so far produced, that is, those containing zinc and magnesium, made their appearance about twenty years ago, and these, with the modified aluminium-silicon alloys, are amongst the most important and interesting that have been developed in the period. The magnesium silicide alloys and those containing magnesium are older groups, but in recent years they have been much improved and largely used in transport, structural and marine applications.

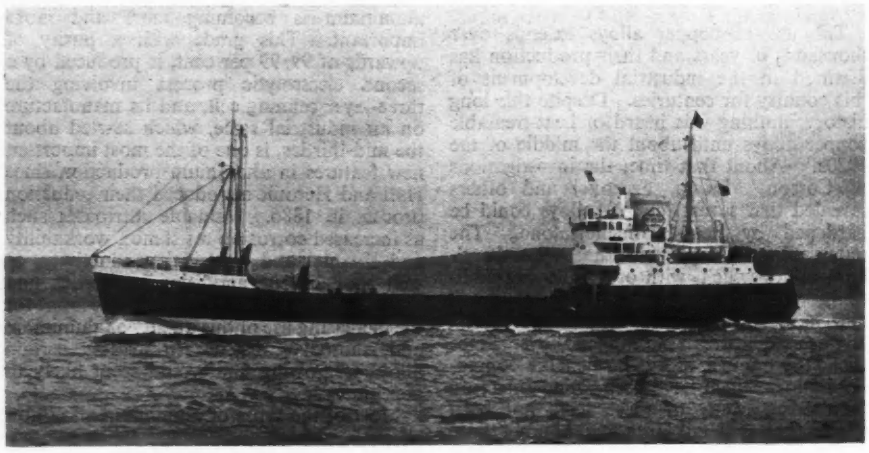
(To be concluded)

Institution of Civil Engineers.—To mark the seventieth anniversary of the Glasgow and West of Scotland Association of the Institution of Civil Engineers, Professor E. C. W. A. Geuze, of the University of Delft, Holland, gave two lectures, which were delivered before the Association in Glasgow on March 11th and 14th. Professor Geuze is professor of soil mechanics and foundations engineering at the Delft University and an eminent consultant on foundation problems. His first lecture was "Foundation Problems in the Low Countries," and explained how, due to the nature of the subsoil, which consists mainly of peat overlying sand, and to the height of the water table, it was very difficult to obtain a stable foundation without resorting to piling. His second lecture was entitled "Problems concerned with the 1953 Floods in the Netherlands." In the course of his address he mentioned that the chances of floods occurring in Holland before the year 2000 on the same scale as those experienced in 1953 were about 500 to 1. Both meetings were very well attended, there being between eighty and 100 members present.

Bulk Cargo Ship "Golden Bay"

The bulk cargo ship T.S.M.V. "Golden Bay" has been designed and built to carry cement or coal in bulk and special equipment has been installed for loading and discharging the cargo. A total of 1200 tons of cement or 1000 tons of coal can be carried, and the ship, which has a length between perpendiculars of 230ft, is propelled at a service speed of 10 knots by two sets of diesel engines, developing a total of 1260 b.h.p., the power being transmitted through electromagnetic coupling alternator unit sets.

BEFORE sailing to New Zealand, the twin-screw bulk cargo ship "Golden Bay" carried out an extensive series of trials at one of the works of the Associated Portland Cement Manufacturers, Ltd., to test the efficiency of the ship's equipment. The ship, built by Henry Robb, Ltd., for the Tarakohe Shipping Company, Ltd., of Wellington, New Zealand, in association with the Golden Bay Cement Company, has been designed to incorporate the special requirements of the owners for the transport of cement in bulk. To handle the cargo expeditiously, mechanical loading and discharging gear has been installed and the object of the trials has been thoroughly to test the capabilities of the equipment to load and discharge cement and to discharge coal, which is an alternative cargo. Our photograph of the ship on trial shows that the machinery is arranged aft, and the following are the main particulars of the new ship: length overall, 245ft 9¾in; length between perpendiculars, 230ft; breadth moulded, 42ft; depth moulded to upper deck, 18ft; service speed, 10 knots; and a deadweight of 1400 tons on a draught of 14ft.



"Golden Bay" on trials

The ship has a single deck and a single hold space divided into two by a middle line bulkhead, which extends for the full length of the compartment. Forward of the holds is a space in which is arranged the special loading and discharging gear, and in the forecastle are the ship's stores. At the aft end of the holds are small compartments to house the tensioning machinery forming part of the hold conveyor system, and over these compartments are the fuel bunkers, having a total capacity of 66 tons. The cellular double bottom extends from the forepeak bulkhead to within the engine-room, and is divided into four tanks, of which Nos. 2 and 3 are divided at the centre line. The capacities of the tanks, which are arranged for water ballast, are: No. 1 50 tons, No. 2 176 tons, No. 3 165 tons, No. 4 51·5 tons, while the forward and aft peak tanks hold 51 tons and 83·5 tons repectively. Each of the two hatches has a clear opening of 80ft by 12ft, and is fitted with MacGregor steel hatch covers, which are operated by the individual pull system, with stowage arranged forward and aft.

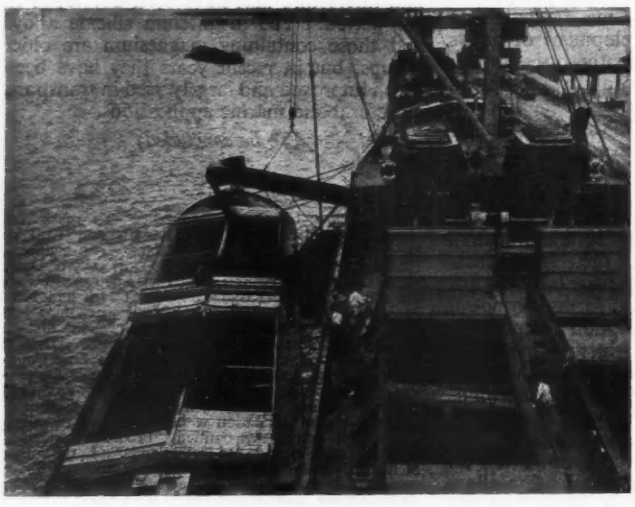
All the accommodation is aft and the crew have single and two-berth cabins on the upper deck and on the same deck are separate messes for the crew and petty officers. Single berth cabins are arranged in a house on the poop for the engineer and other officers, together with their mess and pantry, a smoke room and the galley. The captain and chief officer have their cabins on the boat deck, and above is the navigating bridge, with the wheelhouse and chart room, which are equipped with a compass outfit supplied by Kelvin and Hughes, Ltd., and radio and radar provided by Marconi International Marine Communication Company, Ltd.

The ship has been built under the survey of Lloyd's Register of Shipping, and about 50 per cent of the structure has been welded, including the double bottom, centre line and transverse bulkheads, decks, seatings and shell butts. The framing and shell seams are riveted. To facilitate the operation of the cargo handling gear, the cargo holds, as illustrated, have a constant cross section over their entire length, and the tank top is of special construction to suit the scrapers and conveyors. Deep cantilever brackets, three frame spaces apart, are fitted in lieu of pillars, to connect the upper deck to the side frames, which are carried into the double bottom and connected directly to the floors.

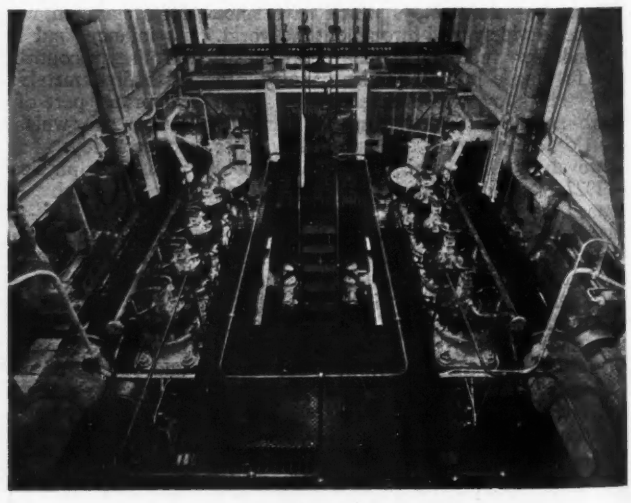
Steering is effected by a tank-tested double blade streamline rudder of large area, operated by electro-hydraulic gear, supplied by Brown Brothers, Ltd. It has two pumping units, either of which is capable of performing full duty. The deck machinery, manufactured by Clarke, Chapman and Co., Ltd., consists of one 3-ton electric winch, located on the upper deck just aft of the forecastle, for working the 5-ton derrick at the foremast; an electric warping capstan, aft on the poop deck, with the driving motor arranged on the upper deck in the steering gear compartment; and an electric windlass for dealing with the two 30·5 cwt bower anchors and 240 fathoms of 1⅛in stud link cable. There is a spare bower anchor of 26 cwt, a stream anchor of 7¼ cwt and 100 fathoms of stud link cable for mooring purposes. For life saving there are two 24ft steel lifeboats, each capable of carrying 32 persons, carried in Welin Maclachlan crescent pattern davits.

Cargo Handling Equipment

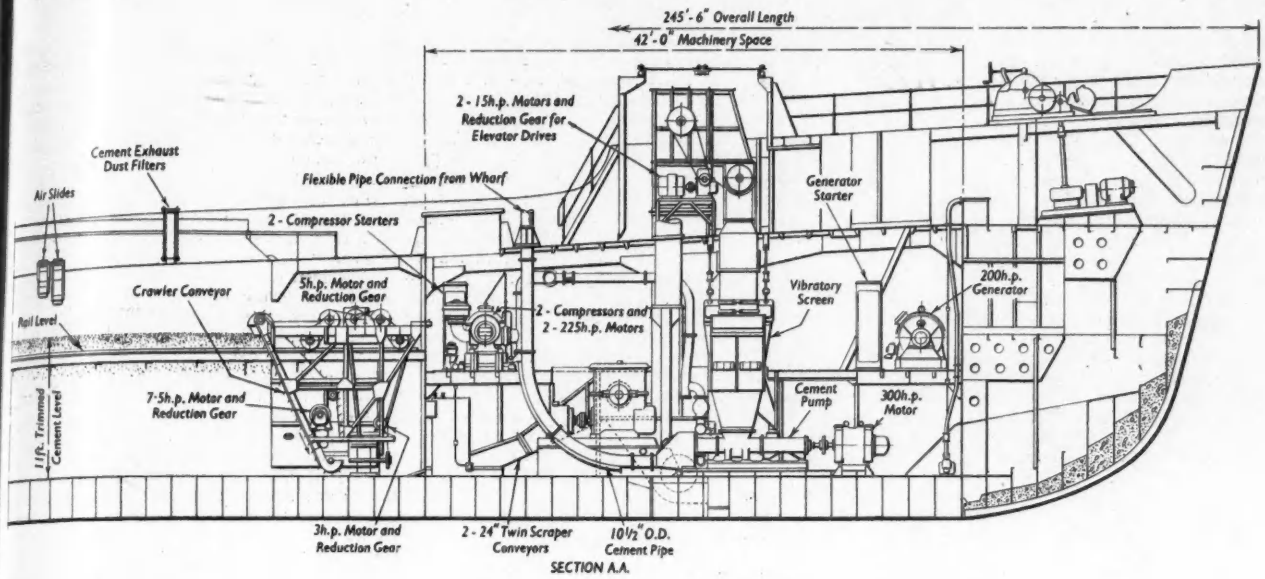
As already stated, the ship has been specially designed and equipped to carry cement or coal in bulk and to be able to load the cement cargo and to discharge both cargoes. The two holds have a total capacity of 1200 tons of cement, which is stowed to a level of 14ft 3⅜in above the base line, or 1000 tons of slack coal. Our line drawing, which is a longitudinal section of the forward end of the ship, shows the general disposition of the cargo handling gear. When loading cement the hatch covers are closed and the cement is delivered to the ship from shore supplies by means of air slide loading booms on the wharf, which are connected to the ship air slide system by telescopic chutes. There are three air slides to each hold, each air slide having a capacity of 60 tons per hour to give an overall loading rate of 360 tons per hour. The slides

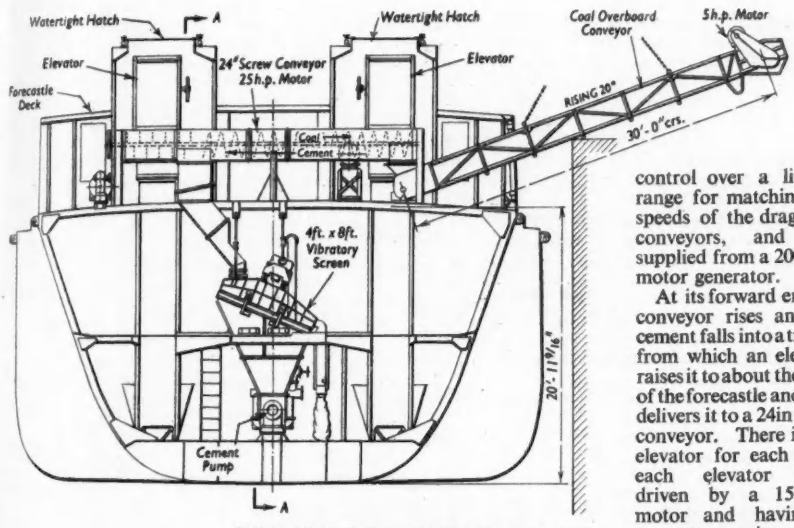


Ship discharging coal into lighters



Main engine-room looking forward





General arrangement of cement and coal handling equipment in the "Golden Bay"

are grouped in pairs, one serving the port and one the starboard hold, and are linked with three fittings arranged at intervals along the length of the port hatch side coaming. Each of these fittings has an attachment to take a flexible air pipe, with a quick release connection, leading from a fan mounted on the wharf. In each hold the unloading machinery consists of a travelling crawler conveyor having an inclined flight and transverse scrapers, carried on rails, and able to travel the full length of the hold. Motive power is supplied by a 5 h.p. motor driving through a reduction gear and the conveyor flight is powered by one 7½ h.p. geared motor, while two 3 h.p. motors, both fitted with reduction gears, actuate the transverse scrapers which draw the cement from the sides of the hold towards the longitudinal scrapers. The duty of each crawler conveyor, which takes about eight hours to traverse the length of the hold and has a capacity of 100 tons of cement per hour or 50/100 tons of coal per hour, is to feed the two drag link scraper conveyors which are fitted in each hold.

To enable the crawler conveyor flights to feed the scraper conveyor without jamming, the scraper conveyor top flight travels from forward to aft and the return flight moves the cement forward. The conveyors each have a capacity of 50 tons of cement or 25/50 tons of coal per hour, and are driven by a 35 h.p. d.c. motor, placed forward, and have a tensioning device fitted in wing compartments at the aft end of the holds. The motors have a separate shunt field control over a limited range for matching the speeds of the drag link conveyors, and are supplied from a 200 h.p. motor generator.

At its forward end the conveyor rises and the cement falls into a trough from which an elevator raises it to about the level of the forecastle and then delivers it to a 24in screw conveyor. There is one elevator for each hold, each elevator being driven by a 15 h.p. motor and having a cement capacity of 100 tons per hour and a coal capacity of 50/100 tons per hour. The screw conveyor, which has a capacity of 200 tons of cement or 100 tons of coal per hour and is powered by a 25 h.p. motor, is mounted horizontally and transversely in the ship and delivers the cement from the port elevator to a trunk feeding a vibratory screen. A short paddle section performs the same duty for the starboard elevator. From the 4ft by 8ft Fraser and Chalmers vibratory screen, the cement passes to a Fuller Kenyon cement pump, which is driven by a 300 h.p. motor and has a capacity of 170 tons of cement per hour. The cement is discharged to deck level through a pipe of 10½in outside diameter and then to the wharf through a flexible pipe by means of air supplied by two compressors, each being driven by a 225 h.p. motor. When carrying coal, the ship is loaded through open hatchways and the discharging arrangements are similar up to the point of delivery to the screw conveyor, which delivers the coal to a 30ft portable belt conveyor on the port side. This unit, which is driven by a 5 h.p. motor, is slung into position between the ship and the jetty by the ship's derrick, the inboard end entering the ship by way of a watertight door in the ship's side above the upper deck. This arrangement can be seen in our line drawing and on page 448 we show the ship undergoing coal unloading trials. All starters for the equipment are operated by push buttons mounted on a dead-front central cargo control panel which has selector switches for coal or cement unloading and provision for sequence or individual starting. Since unloading is a continuous process each drive is electrically interlocked with the previous operation to ensure that should a stoppage occur no further cargo is delivered to that point. However, beyond that point all the succeeding unloading stages continue to operate so as to clear away any blockage which may have occurred.

Main and Auxiliary Machinery

The power necessary to propel the ship is developed by two British Polar Mark M44M, two-stroke, single-acting diesel engines having four cylinders of 13¾in diameter by 22¾in stroke. On page 448 we show a general view of the engine-room looking down on the cylinder tops. Each engine develops 630 b.h.p. at 250 r.p.m. and the power is transmitted to the propeller through electromagnetic coupling alternator units supplied by the British Thomson-Houston Company, Ltd. The couplings (as described on page 458) serve a dual purpose: they operate as normal electromagnetic couplings when the ship is at sea, and as alternators, for supplying the electrical power required for the cargo handling machinery when the ship is in port. When used for the latter purpose a steel wedge is employed and

Port hold looking forward towards the crawler conveyor and showing the twin slat conveyor

engages in a slot cut in the rim of the outer member to lock it stationary. Electrical connections are then made to the three-phase windings of each outer member and each unit becomes a conventional alternator driven by one of the main engines. The alternators each develop 500kW at 440V, three-phase, 50 cycles when driven at 300 r.p.m. The engine manufacturer has supplied three starting air receivers, also two heat exchangers and two lubricating oil coolers and the Alfa-Laval Company, Ltd., has provided a fuel oil purifier and a lubricating oil purifier, both of 200 gallons per hour capacity, and a lubricating oil heater. There is a Reavell electrically driven air compressor rated to deliver 35 cubic feet of free air per minute at 350 lb per square inch, and a diesel-driven air compressor of 5·2 cubic feet capacity, together with an auxiliary air receiver provided by the Russell Newbery Company, Ltd. This company has also manufactured the six-cylinder diesel engines, each of 105 b.h.p. at 1050 r.p.m., for driving the three B.T.H. 60/70kW generators, and a three-cylinder diesel engine of 52·5 b.h.p. for driving a 30kW B.T.H. generator, all of which supply the power required for the ship's auxiliaries. All the pumps, which are electrically driven, were manufactured by Drysdale and Co., Ltd., and include a 50 tons per hour general service pump ; a 45 tons per hour standby fresh water or circulating water pump ; a ballast pump of 220 tons per hour capacity, which can be used, if required, to assist in trimming the ship ; two 3 tons per hour pumps, one for domestic fresh water and one for sanitary service, and a fuel oil transfer pump, rated to deliver 3 tons per hour. There are two daily service fuel tanks, each of 2·3 tons capacity arranged at upper deck level ; a Streamline filter, of 10 gallons per hour capacity, mounted in the casings at the poop deck, and two lubricating oil tanks, each having a volume of 140 cubic feet, located one to port and one to starboard at the forward end of the engine-room.

Progress of the Radio Telescope at Jodrell Bank

WE were recently invited by the Department of Scientific and Industrial Research to visit Manchester University's experimental station at Jodrell Bank, where the construction of a large radio telescope is in progress. The way in which this instrument will be used to study the so-called radio stars and for research generally in radio astronomy was discussed in an article in THE ENGINEER of May 9, 1952 ; the proposal for the radio telescope at Jodrell Bank was described at that time, and in our issue of June 25, 1954. It is expected that this new instrument will permit exploration of regions of the universe 500 to 1000 times greater in extent than is possible with optical telescopes.

Briefly, the radio telescope will consist of a paraboloidal reflecting mesh, held in a steel bowl. The bowl will be 250ft in diameter and 62ft 6in deep and is to be carried by a beam spanning between two towers, so that its centre will be 185ft above the ground. The beam is to be carried in bearings at the tower tops, thus allowing adjustment of the angular elevation of the bowl, and the towers themselves will be mounted on a circular rail track, to give azimuth motion. Thus, the telescope will follow any desired track or point in space, as the earth rotates ; it will be driven by electric motors controlled on the metadyne principle. Electronic control circuits will give automatic sidereal motion and other scanning movements.

At the present stage of construction, interest is naturally concentrated on the structure of the radio telescope. A structure was needed which would withstand high winds, and in which deflections could be kept small. Normal structural steel was therefore considered the best choice of material, and the detailing has been arranged so that the stresses are lower than is usual in steelwork practice, thus keeping within the allowable limits for deflections.

The two towers will be carried, in the finished structure, on twelve bogies, eight of which will run on a circular rail track 310ft in diameter, and four on an outer track of larger diameter. The piled foundations of the track extend to marl at a depth of 90ft, so that they are independent of the shrinkable clay at lesser depths. The rails are accurately set and the rollers of the bogies are slightly tapered, so that there is no differential action between the bogies of the inner and outer tracks.

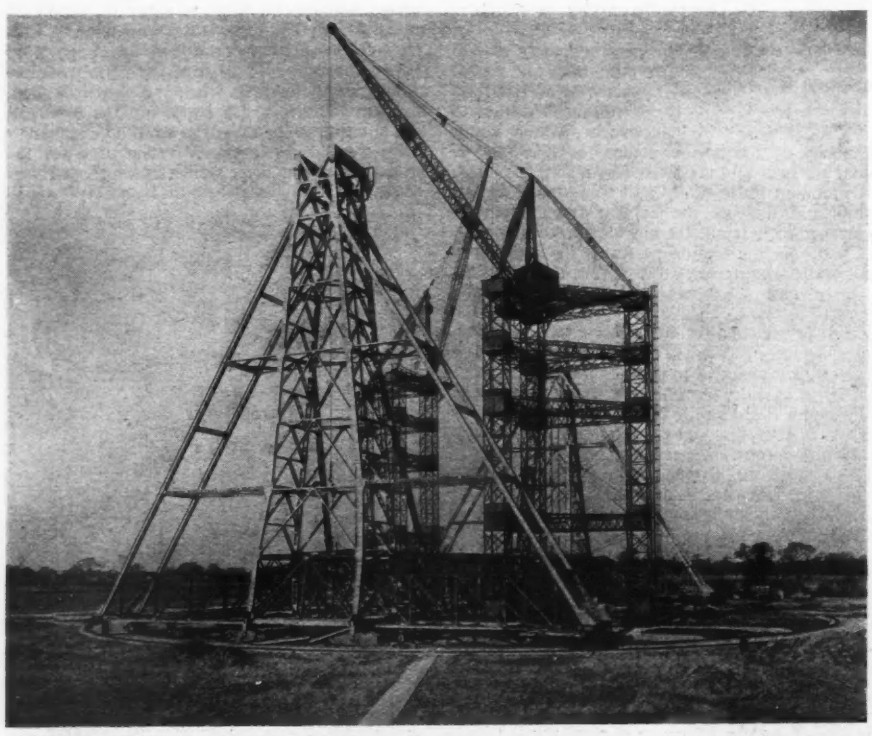
Stability against winds has been achieved by connecting the two towers together at ground level by a deep-framed girder, and by building outriggers on to each tower. These elements are clearly shown in the illustration. The two bogies under each tower, on the inner track, will normally carry most of the deadweight of the structure, a load of 400 tons being envisaged for a single bogie. The outrigger bogies will come into play when winds have to be resisted ; there are four of them for each tower, one at the base of each of the principal outrigger struts.

There are no flanges on the bogie rollers, and horizontal loads are taken by a pivot and thrust bearing at the centre of the structure under the main cross beam. This arrangement allows the telescope to remain true for a certain deflection of the structure, and also takes care of temperature movements, since the whole structure is free to expand or contract about this central point of anchorage. It can be seen from the illustration that the steelwork detailing follows along normal lines, with riveted connections ; deep " N "-braced beams connect the outrigger struts with the base of the tower, and there are similar members connecting the out-riggers with the centre part of the main cross beam.

The main beam, which will carry the telescope and bear on the tops of the two towers, will also be substantially built. It will be carried by 30in diameter shafts on self-aligning split roller bearings. There will be a 70ft deep girder round the perimeter of the dome, connected by radial ribs to a smaller, central girder. Erection of the dome is expected to proceed so that it is built up symmetrically, and will thus not be liable to unbalanced wind forces.

The total weight of steel in the completed structure will be about 2000 tons. Wind tunnel tests were carried out on a model, with particular attention to dynamic effects and resonant vibrations, but it was found that no serious resonant vibrations were caused by winds below the equivalent of 200 m.p.h. This extreme case gave a horizontal force on the central bearing of about 400 tons, which in fact it can sustain. Normally, it is expected that deflections of the structure will be limited to about $\frac{1}{16}$in, we are informed, during operating conditions, but deflections up to $\frac{1}{2}$in may be experienced during gales. Erection is due to be completed this year.

The radio telescope is being built for Professor A. C. B. Lovell, professor of radio-astronomy at Manchester University, who is in charge of research at Jodrell Bank. The telescope has been designed by the consulting engineers Husband and Co., and the contractor concerned with the steelwork construction is the United Steel Structural Company, Ltd.



Erection of the two towers of the radio telescope is here shown in progress. The towers will move on bogies on a circular track. They are connected at ground level by a stiffening beam, and they have outriggers to resist wind loads

Book of Reference

Electrical Trades Directory : The Electrical Journal Blue Book, 1955. Edited by Norman H. Codling, A.M.I.E.E. London : Benn Brothers, Ltd., 154, Fleet Street, E.C.4. Price 50s.—This, the seventy-third edition of the *Electrical Trades Directory*, contains 65,000 references, covering the activities of the electrical and allied industries and trades, and the products and services that they offer. The information is classified into thirteen sections, and is well indexed. Increases will be found in the references relating to engineers, electrical installation contractors, electrical and radio wholesalers and distributors, and, in particular, to the list of manufacturers which now totals 6600. The section devoted to " Products and Materials " now contains 45,000 references, under 2180 headings, including, for example, 150 makers of electronic instruments and sixty makers of electronic control gear. More than 5300 patented products are listed in the section on trade names. Details are given of the members and officers of the Central Electricity Authority (formerly known as the British Electricity Authority), its Generating Divisions and main power stations, the Area Electricity Boards, the National Coal Board and London Transport. Prominent personalities in the electrical industry are among the 3300 names given in the personal section of the book.

International Conference on the Peaceful Uses of Atomic Energy

We learn that the United Kingdom Government has accepted the invitation extended by the United Nations to eighty-four countries to participate in a conference on the peaceful uses of atomic energy, to open in Geneva on August 8th under the presidency of Dr. H. J. Bhabha, Director of the Tata Institute of Fundamental Research, Bombay, and secretary of the Indian Atomic Energy Commission. Professor W. G. Whitman, Head of the Department of Chemical Engineering at the Massachusetts Institute of Technology, will be secretary-general of the conference, and in this capacity will serve as an officer of the U.N. Secretariat, assisted by a three-man working party.

The conference, which is an outcome of proposals laid before the United Nations by President Eisenhower in December, 1953, when he urged the need for international co-operation to apply the benefits of atomic energy to world peace, will be devoted to the presentation and discussion of papers on a number of main subjects related to the peaceful uses of atomic energy.* It is intended that subjects will be dealt with and presented only from the scientific and technical points of view.

The United Kingdom Papers Committee, which has been set up under the chairmanship of Sir John Cockcroft, Director of the Atomic Energy Research Establishment, Harwell, to integrate the United Kingdom's contribution to the conference, has drawn up a provisional list of papers and authors covering the majority of topics to be discussed. The committee will be pleased to receive suggestions for titles and authors of additional papers, and communications should be addressed to the Secretary of the Papers Committee, Dr. J. Gaunt, Atomic Energy Research Establishment, Harwell, Didcot, Berks. The final choice of papers will lie with the United Nations Advisory Committee, who are responsible for advising on conference arrangements.

It is unlikely that time will permit more than a small fraction of papers to be presented verbally, but all accepted papers will be published in the proceedings of the conference. Owing to shortage of accommodation it is not certain that authors of papers will be able to attend all the sessions of the conference, even if their paper is accepted for verbal presentation.

The United Kingdom Government proposes to contribute to the exhibition to be held in Geneva during the conference.

A summary of the principal topics to be discussed is given in the following paragraphs.

Two sessions will be devoted to the need for new power sources and they will include papers surveying estimated world power requirements in the years 1975–2000, alternative power sources, and individual countries' needs and potentialities for power and heat. Another session will be concerned with a discussion of the maximum plausible role which nuclear energy can play as a source during the next twenty-five to fifty years.

The building of a nuclear energy enterprise will be the subject of a group of papers dealing with capital investment required for nuclear energy and experience obtained from existing nuclear power plant with reference to the ways of developing atomic power.

Health and safety will be discussed from three aspects—biological effects of radiation, ecological considerations related to nuclear energy, and reactor safety and the siting of power reactors. In a group of papers on the production and use of isotopes consideration will be given to the importance of isotopes in industry, medicine, biology and agriculture, and to the problems of waste disposal. The problems involved in the handling of large quantities of radioactive substances will be dealt with in a separate session.

The subject of reactors will be subdivided into two broad groups concerned respectively, with research reactors and power reactors. In the latter class it is proposed to include papers surveying fuel cycles and types of reactors and papers dealing with fast neutron reactors and thermal neutron reactors, using natural uranium, enriched uranium U233 and recycled fuels. Papers are invited, to cover at least the following :—Liquid-metal-fuel reactor, aqueous homogeneous reactor, boiling water reactor, "fluidised" solid-fuel reactor, sodium-cooled reactor, pressurised water reactor and beryllium-moderated reactor. It is proposed to give descriptions of prototype reactors, including construction costs, problems of pumping, corrosion and control, particular attention being given to the way in which the results of experiments on prototypes are to be interpreted in evaluating the final design of full-scale systems.

Separate sessions will be devoted to special technologies, such as methods of prospecting for uranium and thorium ; chemical treatment of low-grade ores and ore concentrates of uranium and thorium ; the production of uranium and thorium metals from high-grade ores and concentrates ; analytical methods applicable to raw material production, and the production technology of special materials, including D_2O, beryllium and beryllium oxide, graphite and the separation of zirconium by separation from hafnium. Further sessions will be concerned with chemical aspects of nuclear reactors, the chemical processing of irradiated uranium and thorium fuel elements (including solvent-extraction processes, high-temperature processing and volatility processes) and the storage and separation of fission products.

Metallurgical matters will be considered in two main sessions. The first will include the metallurgy of thorium, uranium and their alloys, and the fabrication of fuel elements, including the canning problem. The second session will be on liquid metals technology, and will include the problems of handling liquid metals, liquid metal heat transfer, and corrosion problems in liquid metal systems.

There will be a number of sessions on each of the following subjects :—Reactor physics, chemistry and metallurgy, including radiation chemistry and radiation damage.

Finally, the applications of radioactive isotopes to research and industrial problems will be examined in detail. One group of papers will deal with the use of isotopes in process and quality control : for example, in extraction columns such as those used in the separation of petroleum hydro-carbons, in materials testing, and in the "automatic" factory. Another group of papers will discuss the industrial utilisation of fission products, the effects of radiation on materials, food sterilisation and the prospects of direct conversion of radiation into electricity.

In the closing plenary session consideration will be given to the possible role of thorium in nuclear energy. There will also be discussion of more general topics, including technical education and training in the field of nuclear engineering.

* *Nature*, February 19th, page 328.

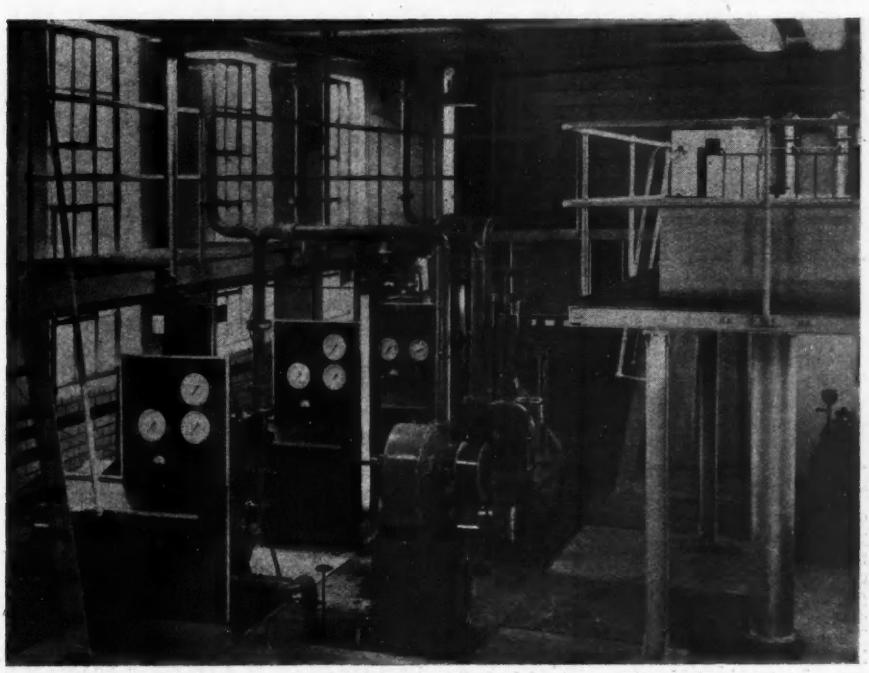
Hydraulics Laboratory at Nottingham University

A SUB-DEPARTMENT for fluid mechanics and heat transfer has been formed in the Mechanical Engineering Department of the University of Nottingham under the direction of Dr. E. Markland. It is intended to train engineers, who, in their final year, will specialise either in fluid mechanics or hydraulic machinery. New hydraulic machinery laboratories and an air flow laboratory are also planned by the university authorities, and the completion of the first stage of these plans was the opening of the new hydraulics laboratory by Mr. C. V. Armitage, managing director of Gwynnes Pumps, Ltd., on March 22nd.

A section of the new laboratory can be seen in the illustration on this page. A sump below the floor provides a suction pit common to all the pumps. The plant installed includes two 2½in centrifugal pumps, one supplying a small Pelton wheel and the other a Francis turbine, a 4in centrifugal pump which delivers directly to the sump, and a 3in centrifugal pump used for supplying a constant head tank on the roof of the building. These pumps are driven by shunt-regulated d.c. motors with swinging field mountings to provide measurement of input torques. The discharge is regulated in each case by a specially constructed spear valve on the delivery side of the pump, and the suction lift may be varied by a further spear valve at the suction pipe intake. Fitted in the delivery pipes from the pumps there are differential pressure flow measuring devices which may be calibrated by directing the appropriate discharge into a volumetric measuring tank. Suction and delivery heads are measured by Bourdon gauges and pump speeds by electrical tachometers.

There is a small single-acting ram pump, provided with air bottles, either of which may be rendered inoperative, on both suction and delivery branches. The discharge pipe of this unit is branched to provide alternative delivery mains of different lengths, both of which discharge into a volumetric measuring tank.

One of the principal pieces of the laboratory's equipment is a 10in axial flow pump which is driven by a d.c. motor controlled by a Ward-Leonard set. The discharge of this pump may be passed through a similar 10in axial flow turbine or may be led to the inlet tank of a flume. This flume is about 15ft long and 3ft wide, and its slope is adjustable between zero and 1 in 15, so that either subcritical or supercritical flow may be produced in it.



Hydraulics machines laboratory at the University of Nottingham

Metallurgical Topics

Copper Steels

In an article by H. Laplanche in *La Métallurgie* for February, 1955, attention is directed to the advantages of the copper-bearing steels which are susceptible to structural hardening, that is to steels containing over 0·6 per cent of copper which is retained in solid solution by cooling and (in part) precipitated by reheating to a lower temperature. The article gives details of the mechanical properties obtainable in three copper-chromium steels and a copper-nickel steel (carbon 0·17 to 0·28 per cent), and a 0·07 per cent carbon copper-nickel-chromium steel. The treatment recommended was air cooling from 900 deg. Cent. followed by reheating for four hours at 500 deg. Cent., in effect a normalising and tempering treatment in which the hardening was not obtained by quenching but by prolonged heating, at a uniform temperature, of the solid solution which could be retained by fairly slow cooling. Similar results were obtained

Table I—*Mechanical Properties of Copper-Chromium Steels**

Composition	C 0·20, Cu 0·90, Cr 0·45 per cent		C 0·28, Cu 1·00, Cr 0·52 per cent			
Treatment	A.C. 900 deg. Cent.	T. 4 hour 500 deg. Cent.	A.C. 900 deg. Cent.	T. 4 hour 500 deg. Cent.	T. 2 hour 600 deg. Cent.	T. 1 hour 650 deg. Cent.
Yield point, tons per square inch	23·5	32·4	29·2	37·4	29·2	27·3
Tensile strength, tons per square inch	35·5	42·0	41·9	48·6	41·4	39·6
Elongation, per cent	20	21	22	17·9	22·7	25·5
Impact value, Mkg/square centi-metre†	14	9	13	6·3	12·7	12·6

* *La Métallurgie*, February, 1955, page 107.

† French Standard Test Piece, notch 1mm radius, 5mm deep.

A.C.=air-cooled. T.=tempered. F.C.=furnace-cooled.

by interrupting the cooling at 500 deg. Cent. and then continuing it after four hours at that temperature. The rate of cooling after the precipitation treatment was immaterial. Some results are given in Table I. It will be seen that the elongation and impact value are improved (with some loss of strength) by a higher tempering temperature than 500 deg. Cent., but with any of the temper-hardening treatments it was possible to obtain uniformity of properties from outside to centre of massive bars of the steel, with the further advantage that deformation due to residual internal stress is avoided.

Several Iron and Steel Institute Research Committees were interested in copper steels, and sponsored work on the subject before the war. Apart from corrosion trials, in which 0·5 per

Table II—*Mechanical Properties of a Copper-Chromium Steel Casting**

Composition	C 0·25, Cu 1·15, Cr 0·96 per cent				
	Air cooled from 950 deg. Cent., and tempered				
Treatment	F.C. 950 deg. Cent.	4 hour 500 deg. Cent.	2 hour 600 deg. Cent.	1 hour 650 deg. Cent.	1 hour 700 deg. Cent.
Yield point, tons per square inch	20·0	34·6	29·6	26·4	24·4
Tensile strength, tons per square inch	36·0	48·0	44·1	41·8	40·8
Elongation, per cent ...	21	8	15	12	20
Izod impact value, ft-lb ...	19	6	20	26	30

* Iron and Steel Institute, Special Report No. 23, page 72.

cent of copper with 1 per cent of chromium produced a considerable improvement in resistance to strongly corroding atmospheres, the effect on mechanical properties was also investigated. A higher copper content than 0·5 per cent is required to produce temper-hardening. The 1 per cent copper-chromium structural steels have mechanical properties, as rolled, which compare favourably with those of high-tensile structural steels high in manganese, and they are not so sensitive to the rate of cooling after normalising. Monsieur Laplanche's article gives quenching from 900 deg. Cent. in water or oil as an alternative to air cooling. Although this may be permissible, though unnecessary, for low carbon steels, in medium carbon steels, which quench-harden considerably, the temper-hardening effect is unlikely to compensate for the rather low hardenability of copper steels. Unlike nickel, copper does not appreciably retard the rate of the austenite→martensite transformation; so that if the steel is to be quenched and tempered, copper-bearing steels are not likely to displace the standard heat-treated alloy steels as materials of construction. In steel castings, however, there is reason to believe that copper can play an important part. Its effect is most marked in low-carbon steel castings. Some results taken from the Third Report of the Steel Castings Research Committee are given in Table II. Allowing for the difference in composition (mainly chromium content), they agree very well with those in Table I. Although the maximum increase in tensile strength was obtained by reheating at 500 deg. Cent., treatment at higher tempering temperatures gave a rather softer material, showing a better combination of properties, and this conclusion would appear to apply also to the wrought steels described by Monsieur Laplanche.

Rhenium

Rhenium was first isolated in 1925. As a "missing element" in the Periodic System, it occupied a position between tungsten and osmium, in the second series below manganese, and was known as dwi-manganese. It occurs chiefly in molybdenite, the sulphide of molybdenum. It was made in kilogram quantities in Germany before the war at a price of the same order as that of platinum. It is said to have a marked hardening effect on the platinum metals, and was used, as an alloy with iridium, for the bearings of fine balances and, as a substitute for osmium, in osmiridium fountain-pen points. The realisation, recently, that rhenium may become available in commercial quantities in the United States has focused attention on the metal. Its

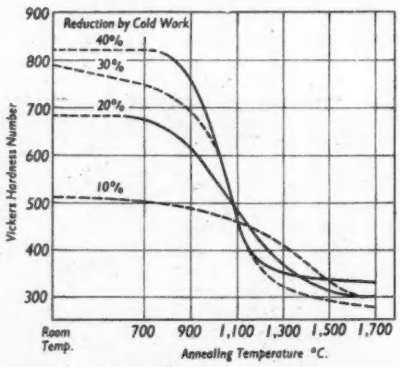


Fig. 1—Effect of annealing for one hour on the hardness of cold-worked rhenium (Sims, Craighead and Jaffee)

chemical properties have already been studied in some detail, but a further investigation of its physical and mechanical properties has been undertaken by the Battelle Memorial Institute and the results have been published by C. T. Sims, C. M. Craighead and R. I. Jaffee.*

The specimens of rhenium investigated were prepared by powder metallurgy technique from the metal powder produced by the reduction of ammonium perrhennate with hydrogen. Sintered bars were made by pressing rhenium powder (particle size 1 to 25 microns) at 30 tons per square inch, presintering in a vacuum at 1200 deg. Cent., and then sintering in hydrogen at 2700 deg. Cent. To attain this temperature, the bars were resistance heated by a current of about 1200A at 6V to 8V. The sintered metal was hot short, thus making hot working impracticable. This was due to a low melting point oxide which readily forms at grain boundaries when rhenium is hot worked in air. No greater success was obtained with rhenium deposited from a rhenium halide on to a hot tungsten wire, or from arc-melted buttons of rhenium, formed by fusion under argon of pieces cut from either the pressed powder or the vapour deposited rod. Cold working was not successful with hot-wire deposited rhenium, and was only partially successful

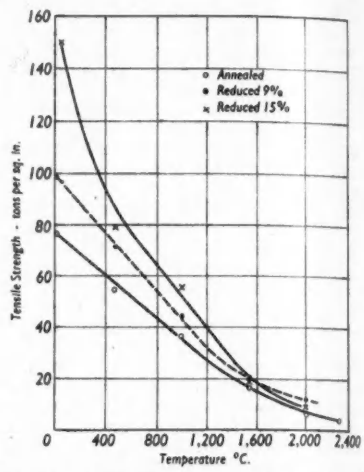


Fig. 2—Tensile strength of annealed and cold-worked rhenium wire at elevated temperatures (Sims, Craighead and Jaffee)

with the arc-cast material. Sintered rhenium bars could, however, be fabricated into rod, wire, sheet and foil by a series of cold-working and annealing operations. About 10 to 20 per cent reduction was given at a time, followed by one or two hours at 1700 deg. to 1750 deg. Cent. to recrystallise the metal and reduce its hardness.

Rhenium work hardens to a greater degree than any known pure metal. Its hardness is increased from 250 to over 800 when the metal is reduced 30 per cent by swaging. It is completely recrystallised, and grain growth begins, at

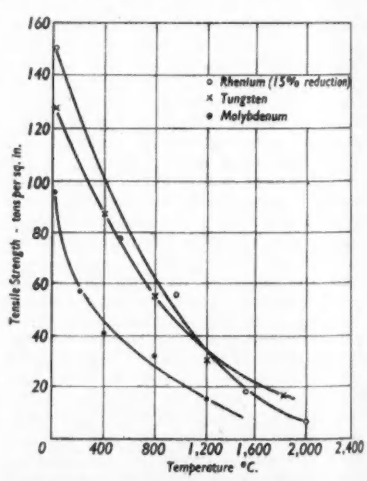


Fig. 3—Tensile strength at elevated temperatures of wrought rhenium, tungsten and molybdenum (Sims, Craighead and Jaffee)

1300–1500 deg. Cent. (Fig. 1), but the grain size is initially very fine, and a temperature of over 1700 deg. Cent. is required to soften the metal to below 300 and make it suitable for further cold work. Rhenium does not tarnish at room temperature but oxidises very rapidly when heated in air. Small specimens, cut from arc-melted

* *Journal of Metals*, January, 1955, page 168.

buttons of rhenium, were heated in air and the loss of weight determined. At 600 deg. Cent. the rate of oxidation became very great, white fumes being given off owing to the formation and volatilisation of Re_2O_7, the highest oxide of rhenium, with a melting point of 297 deg. Cent. In neutral atmospheres, however, rhenium is stable to a high temperature. Several of its physical properties were determined. Some of these showed substantial differences from values hitherto adopted, but this is probably due to the sounder and more massive specimens available. The melting point was 3180±20 deg. Cent. The measured value of the density was 21·02, as compared with the theoretical value derived from X-ray measurements of 21·04. The electrical resistivity at 20 deg. Cent. was 19·14 microhm-centimetre, increasing with increased cold work. The mean thermal coefficient of expansion between 20 deg. and 1000 deg. Cent. was $6{\cdot}8\times10^{-6}$ per deg. Cent. The spectral emissivity decreased in a straight line with temperature from 0·42 at 1400 deg. Cent. to 0·36 at 2800 deg. Cent. The modulus of elasticity in tension was $66{\cdot}7\ (\pm2{\cdot}9)\times10^6$ lb per square inch.

Tensile tests on annealed rhenium at room temperature gave the following results :—

0·1 per cent yield strength	18·7 tons per square inch
0·2 per cent yield strength	20·5 tons per square inch
Ultimate tensile strength	73·2 tons per square inch
Elongation	24 per cent
Reduction of area	20 per cent

The large spread between yield and ultimate strength reflects the high work-hardening capacity of rhenium. A reduction of 15 per cent by cold work raises the tensile strength to 150 tons per square inch. Tests at elevated temperatures were carried out in dry helium on 4in—5in lengths of 50 mil—68 mil diameter wire, the metal being heated by self-resistance. Results are shown in Fig. 2. Above 1500 deg. Cent. recrystallisation occurs, reducing the strength of the cold-worked material to that of annealed rhenium at the same temperature. A comparison of rhenium reduced 15 per cent with tungsten of about the same tensile strength and with wrought molybdenum is made in Fig. 3, but whereas molybdenum and tungsten show an increase in elongation from about 3 to 6 per cent as the temperature rises to 1200 deg. Cent., rhenium shows a fall from about 5 per cent to 1 or 2 per cent. Tensile tests were not made on rhenium reduced more than 15 per cent by cold work. It seems possible that a fine, fully cold-drawn rhenium wire might have a tensile strength equal to, or greater than, the 300 tons per square inch obtainable in 0·5 mil tungsten wire.

A number of potential commercial uses for rhenium are pointed out, mainly of an electrical or electronic nature. When available in sufficient amount, it may serve as electron tube filaments, cathodic emitters or as an electrical contact material. Rhenium, or its alloys with the platinum metals, also has potential uses in high wear-resisting parts such as precision instrument points. Its possible use for high-temperature thermocouples is also referred to, but other reports state that rhenium alloys have been tried for this purpose and that, as rhenium seems to be appreciably volatile at 1000 deg. Cent., its use was limited. At high temperatures, rhenium, like molybdenum, must be protected from oxidation by the atmosphere.

Ductile Chromium

THE production of chromium which is ductile at room temperature has been the subject of many investigations, but, until recently, these have all been unsuccessful. During the last few years, however, some promising results have been obtained on a small scale. The first indications of ductility were observed in chromium made by the reduction of chromium chloride by magnesium, but a more suitable source appears to be electrolysis (Greenaway[1]) and treatment with hydrogen (Gilbert, Johansen and Nelson[2]). Another method, the iodide dissociation method, would probably furnish ductile material, but so far only individual grains have been reported as possessing ductility.[3]

The preparation of ductile chromium depends not only on the production of metal of high purity, particularly as regards oxygen, but also on the development of certain techniques in hot and cold working and in the treatment of the metal. H. Johansen and G. Asai[4] have now given details of the method by which they have obtained ductile chromium in the form of wire, rod and sheet. The method was applied to chromium prepared by hydrogen treatment of commercial electrolytic chromium of purity better than 99·95 per cent, and the mechanical working of the arc-melted ingot and its treatment during working are described in detail. At some stages the sheathing of the rod or forging in a mild steel sheath was found to be essential. Initially the products were brittle, but the removal of the surface layers of rod, sheet or wire resulted in a remarkable increase in the ductility of the specimen. This effect had already been noted by W. L. Wain and F. Henderson,[5] who reported a spectacular increase in the ductility of specimens of chromium sheet as a result of etching the surface. Some samples could be bent through 180 deg. and back again quite rapidly before fracture occurred. Johansen and Asai[4] have now found that the method of removing the surface is immaterial. Mechanical, chemical or electrolytic means may be employed, but electrolytic etching was found to give the most satisfactory results. Room temperature tensile tests on chromium wire, drawn at 400 deg. Cent. from 0·23in diameter rod, showed after 40 per cent reduction, about 31 tons per square inch tensile strength with 25 per cent elongation on 1in, and after about 90 per cent reduction, 44·5 tons per square inch with 7 to 10 per cent elongation (or 2 to 3 per cent in specimens which broke outside the gauge length). Attempts to obtain a ductile 1 per cent nickel-chromium alloy were not successful, but 1 per cent iron-chromium wire was obtained in a ductile condition, though iron increased the work-hardening effect during wire drawing, and the permissible reduction in area with the iron alloy during wire drawing at 400 deg. Cent. was only about half that allowed with pure chromium.

It has been asserted that oxygen has little influence on the transition temperature of tough to brittle chromium, and that iron on the surface of the chromium, obtained from the steel sheath in rolling operations, may be the cause of brittleness. Johansen and Asai agree that oxygen may not be the sole cause, though the fact remains that the only room temperature ductile chromium so far produced has had a low oxygen content. Iron in high concentration on the surface, as from sheath rolling, may contribute to the brittleness. Dr. A. H. Sully and his co-workers[6] found that 1 per cent of iron produced a substantial rise in the transition temperature, but the experiments of Johansen and Asai with the 1 per cent iron alloy appeared to give material as ductile at room temperature as pure chromium. So far no clear explanation of the surface phenomenon which causes brittleness has been obtained. While the work described is an interesting development, much remains to be done before any practical application of chromium metal can be achieved, and still more before chromium-based alloys of enhanced strength can be regarded as engineering materials.

REFERENCES

[1] *Journal Inst. Metals*, 1951, Vol. 80, page 109.
[2] *Journal of Metals*, 1953, Vol. 5, page 63.
[3] *Journal Electrochemical Society*, 1953, Vol. 100, page 152.
[4] *Journal Electrochemical Society*, December, 1954, Vol. 101, page 604.
[5] *Proc. Physical Society*, 1953, Vol. 66 B, page 515.
[6] *Journal Inst. Metals*, 1953, Vol. 81, page 585.

Hardness and Crystal Structure

ALTHOUGH it is recognised that the crystal lattice structure of a metal influences its strength, evidence of a sudden change in mechanical properties of pure metals at the temperature of their allotropic transformations is somewhat rare. Rosenhain and Humfrey found a decrease in plastic deformation under stress at the temperature at which α-iron transformed, and Sauveur concluded that the α→γ transformation in iron was accompanied by increased strength and stiffness, and decreased ductility. Nadai and Manjoine, also, carried out tensile tests on pure iron which showed an increase in strength at 900 deg. Cent.

Evidence for a discontinuous change in hardness accompanying a change in crystal habit has now been sought by W. Chubb.*

Hot-hardness tests were carried out in a specially designed, dead-weight hardness testing machine, operating on heated specimens in a vacuum chamber. The machine was fitted with a 136 deg. pyramid sapphire-tipped indentor, heated to approximately the same temperature as the specimen. It was calibrated at room temperature against a Vickers hardness testing machine. They gave results in close agreement. Loads were applied for ten seconds. Hot-hardness tests were made on Armco iron, and on a 0·08 per cent carbon steel with results shown in Fig. 1. Armco iron continued to soften up to 910 deg. Cent. At that temperature, at which the body-centred cubic structure changed to the face-centred cubic, there was a sudden rise in hardness as γ-iron was formed with a hardness equal to that of α-iron at 730 deg. Cent. In the 0·08 per cent carbon steel, the hardness fell with rising temperatures at about the same rate as in Armco iron up to 825 deg. Cent., above which the stiffening effect of the γ-iron formed became apparent.

Evidence was also obtained with other metals. Titanium and zirconium (both prepared by the iodide process) showed a sudden fall in hardness at the temperature at which they passed from the close-packed hexagonal to the body-centred cubic form. Uranium presented a striking

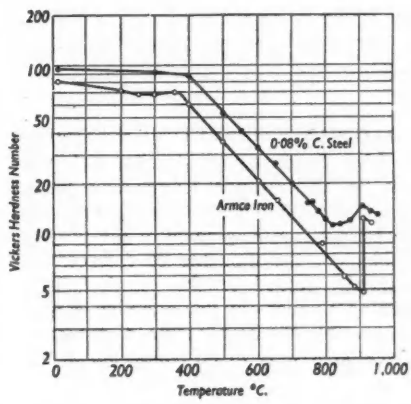


Fig. 1—Hardness tests at high temperatures (Chubb)

example, the hardness showing a rise when the structure changed from orthorhombic to tetragonal at 660 deg. Cent. and a very pronounced fall at 795 deg. Cent. when the structure changes from tetragonal to body-centred cubic.

In cobalt, the change at 420 deg. Cent. was accompanied by a negligibly small increase in hardness. The change, however, is from close-packed hexagonal to face-centred cubic, and the smallness of the effect is not surprising in view of the close similarity of the two structures and of the fact that the completion of the change (as shown by Edwards and Lipson) is a much slower process than it is in most allotropic changes in pure metals.

The example quoted in which thallium was supposed to show a discontinuous fall in hardness at about 230 deg. Cent. is not reliable since the fall in hardness, though relatively large, is really minute on account of the extreme softness of the metal, and thallium has neither of the structures attributed to it, but is face-centred cubic at all temperatures. The general conclusion was that the body-centred cubic structure was always the weaker, when it was one of the phases involved in a transformation. The suggestion is made in the paper that the other structures contribute more to the strength of the material (not that they will always be stronger because other factors are involved), but, for example, that alloys based on face-centred cubic modifications tend to have better strength at high temperatures than those based on body-centred cubic modifications. In support of this idea, the author quotes the "austenitic" and "ferritic" alloys of iron.

* *Journal of Metals*, January 1955, page 189.

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RAILWAY ENGINEERING MANPOWER

After the first whole-hearted welcome to the British Transport Commission plan for modernisation of the railways, and not a little surprise at the magnitude of the projects it contained, the thoughts of engineers have naturally turned to the practical task of getting it under way and attaining as quickly as possible the high degree of productivity essential if it is to be completed in fifteen years. High production rates will not be confined to the manufacturing firms supplying locomotives, carriages, wagons, rails, signalling, and all the specialised accessories needed for the complete equipment of those major items. If speeds of at least 100 m.p.h. are to become as common as the plan suggests a vast amount of work will be necessary on the track alone—work that must be done by railway staff under the skilled supervision of men who have spent their life on the permanent way. Then there are the signalling works. While the execution of a particular scheme may be let out to contract, the preparation of that scheme with all its close co-ordination with the operating department, and with other engineers, may take months of careful work in the office before any contractor can be asked to tender. And yet the plan includes an allocation of £100 million for signalling, telecommunications and automatic train control to be spent within fifteen years. Clearly the signalling staffs of the railways have a severe task ahead of them. The departments of the regional chief mechanical and electrical engineers will need something akin to complete remodelling, the electrical sections being greatly expanded, and the mechanical prepared for the gradual changeover from steam to diesel. Concurrent with the need to keep steam locomotives in first-class order for as long as they are likely to be required will be the necessity of re-planning shops and running sheds for entirely new methods of repair and maintenance. Superimposed upon this will be the scientific planning of the new train schedules, a task that is now the province of locomotive engineers. With British industry as busy as it is to-day one might well ask where the additional men needed are to be found.

To a senior locomotive officer, for example, harassed with a welter of bristling day-to-day problems, of material supply, labour shortage, coal, and the spectre of failures on the road the prospect might appear daunting. Similarly a manufacturing company that is already extended to the limit of its productive capacity could feel equally nonplussed at the idea of having a huge programme of deliveries of a staple product superimposed upon all existing commitments. Yet neither the railway engineer nor the manufacturer can falter in face of the challenge. For both it is the opportunity of a lifetime, to build once again in the spirit of those vast pioneer railway works of 120 years ago, when colossal feats both of organisation and productivity were successfully achieved. But although they were venturing into the unknown, on a scale that seems incredible to-day in view of their almost non-existent experience, men like the Stephensons, Brunel and Locke had no difficulty in attracting the young men of their day to their ranks, and as for labour there were the canal makers, the "navigators," as they were called—as tough and brawny a race as one could wish to find; and with their experience in building and excavating heavy earthworks they made an ideal spearhead of the vast force of railway labourers that was to grow up within a very few years. At the present time and for many years back the British railways have been starved of first-class technical men. Elsewhere the class of work, and the prospects, have been so much more attractive that only those for whom railways have a particular fascination have stayed. The Commission evidently hopes to attract at least some of them back again. Never in the whole history of railways in this country have the prospects for young engineers been so bright, since the fifteen-year plan announced is only a beginning. Nor are the prospects any less pleasurable for manufacturers, since the expansion of their output, virtually assured for so substantial a period, will enable new machinery and quantity-production methods to be introduced where these have hitherto been precluded. Such improved facilities in turn will equip their owners more appropriately for competition in the export trade in railway equipment, to the further advantage of this country. One shadow alone overlies this fair prospect. The Commission might, very wrongly in our opinion, decide that the railways should build diesel locomotives for themselves; or, far worse, contemplate a disastrous policy of importing diesels from abroad.

Every possible source of technical staff and labour will have to be explored; but from wherever they are recruited it is fairly certain that those coming in will have neither practical railway experience nor the specialised "know-how" of the railway manufacturing industry. To effect the necessary training in the shortest possible time will mean the wide deployment of the existing specialised talent and experience, and the chance will come again for young engineers still in their "twenties" to take positions of considerable responsibility in railway work. A still greater responsibility will rest upon the older men, for they will have the task of picking out, at a much earlier age than has hitherto been possible, young men capable of taking responsibility and of organising the work of staff or labour. Inevitably one looks back to the pioneer days of railways, to the beginnings of the Great Western, for example, when the combined ages of Brunel and Gooch—chief engineer and locomotive superintendent respectively—did not reach fifty. While it is not likely, even in the rapid evolution that is inevitable in the next dozen years, that so startling a combination will be repeated, the parallel circumstances are undoubtedly present to-day, and in the railway manufacturing firms many young men are already filling posts of high responsibility with distinction and success. But the opportunities of to-day are not confined to those already in the industry, either on the railways themselves or in the supply trades. To use military parlance, subalterns gazetted in the first phase of the Plan may well be the battalion commanders of five years hence. Those coming in fresh may be puzzled a little on meeting the railway tradition, and may at first be a little impatient; but despite the many years of virtual stagnation the railways to-day possess in their technical staffs a solid core of experience, and the tradition of safe working without which all else would be in vain. Around that solid core the new organisation may be built with confidence.

HYDRAULIC TRANSPORT OF SOLIDS

In the engineering profession we have learnt to put up with unknowns. Even now, despite the existence of very many research establishments, much engineering design still has to be founded upon past experience, inspired guesses, or the adoption, if circumstances will permit, of dimensions so liberal that they should be safe to take care of any unforeseen circumstance. How much, we wonder, was precisely calculable when the design of Calder Hall nuclear power station was

begun? In the past, of course, engineers had even less information to work upon than they have now. About the only thing Newcomen knew about steam when he built the first steam engine was that its condensation created a vacuum. On that basis he devised an engine the design of which was not significantly altered for the next hundred years. Some two hundred years after Newcomen's invention the fact that aerodynamic knowledge was not available did not deter Parsons from building practicable steam turbines and designing highly efficient turbine blading. Again, it is only within the present century that engineers have really begun to recognise the existence of fatigue phenomena ; yet what a wealth of devices were constructed and operated for years to everyone's satisfaction despite complete ignorance about it ! It is, indeed, part of the job of engineers to design and make devices in spite of lack of precise knowledge about the ways in which they work. That is why the attitude of an engineer towards any idea, once conceived, has been not, first of all, to work out all its theoretical implications but to build a model and see if it works. Nor even in this more theoretical day is that attitude without its value. For though, indeed, much can be found out by theoretical investigation, before a trial is made, only a trial can reveal all the snags that may be encountered and only usage of a device can reveal about some of its features whether further theoretical investigation is really worth while or not.

For a great many years solids of various kinds have been transported by hydraulic carriage in pipes. Someone conceived, perhaps seventy-five or more years ago, that mud and sand could be dredged from estuaries and harbours by lowering a pipe almost to the bottom and pumping up a mixture of water and silt or sand. The idea proved successful ; and the process was subsequently developed for land reclamation by pumping the material thus lifted quite long distances to the margin of the sea or lake. Some twenty-five years ago, as Mr. Silk remarked in a discussion before the Institution of Mechanical Engineers last Friday, the high-pressure sluicing system for ash handling was introduced into this country and it is now used for conveying material up to 5 miles for disposal. As much as 15,000,000 tons of solids may be so handled each year in this country. The same system has been used for shifting earth and for transporting sand and gravel and other minerals. Yet, to judge by the bibliography accompanying the paper presented by Worster and Denny, at the "Mechanicals" last Friday, it is only within the few years since the end of the second world war that really serious attempts have been made to elucidate the theoretical factors involved. Design, so far, has been based upon experience and the empiricism that experience breeds. But for some reason, possibly not unconnected with the raising of coal from mines, interest in the possibilities of the system has recently been growing and investigations have been started in several countries. For those who are advocating the use of this system have found that, where it will need to compete with established systems, as, for example, in lifting coal from a pit to the surface, data are lacking both for the design of a plant to meet given conditions and about the economy and the cost of operation.

Many factors enter into the problem of hydraulic conveyance. The concentration of solids in the liquid, the degree of stratification within the pipe, the size of the individual particles (which has an influence on the power required), and the material from which the pipe is constructed, all have an influence. The characteristics of the pump employed need to be suited to the system and it is a help if the pump characteristic is steep near its working part. The maximum size of particle that can be passed through a pipe of given diameter is not easy to determine since it depends, apparently upon such factors as the concentration, the flow velocity and the mixture of sizes of particles that may be present. On the more practical side wear on the pipe and on the pump impeller have to be taken into account ; and friable material, such as coal, may be subjected to degradation in size. If the material is not to be passed through the pump means must be provided for introducing the solids into the water which will be under high pressure. That is a problem of great practical interest if coal is to be transported from a pit bottom. Perhaps it will be illuminated by the small pilot plant that is now being installed at a colliery in Scotland. We cannot enter here into discussion of all the factors involved and further reference should be made to the paper by Worster and Denny already mentioned. But their conclusions are of interest. "The outstanding characteristics of hydraulic transport systems are the large power required and the high capacity of pipes of quite modest size. For instance . . . the pressure drop along a 12in pipe conveying coal may exceed 300ft per mile, but the capacity is of the order of 250/300 tons per hour of 3in or 4in coal." No wonder the Coal Board is interested ! Moreover, "calculations indicate that the efficiency of . . . a lifting system need be little less than that of the ordinary winding method" and "other advantages . . . lie in the possibility of greatly reduced health and fire hazards due to dry coal dust."

Obituary

ENGINEER REAR-ADMIRAL W. M. WHAYMAN

It is with regret that we record the death of Engineer Rear-Admiral William Mathias Whayman, C.B., C.B.E., which occurred on Monday of last week. Admiral Whayman, who retired from the Navy in 1927, was born in August, 1871, and after receiving his early education at Sir Joseph Williamson's Mathematical School at Rochester, became an engineering student at the Royal Naval Engineering College at Devonport Dockyard during the years 1886 to 1891. During the next three years he took the advanced engineering course at the Royal Naval College, Greenwich, and then was appointed an assistant engineer on board the battleship H.M.S. "Royal Sovereign." After serving two years in this ship he spent the next year as engineer officer in the H.M.S. "Grafton," and H.M.S. "Immortalité," and from 1897 to 1900 was engineer in charge of H.M.S. "Linnet." For the next five years Admiral Whayman was at the Admiralty and was mainly concerned with the development of water-tube boilers, and then he returned to sea in the cruiser H.M.S. "Argonaut," and while on board was promoted to Engineer Commander. He came ashore again in 1908, first to Portsmouth Dockyard, then to the Admiralty Controller's department and then, from 1909 to 1913, he was engaged in supervising the machinery of new battleships, including the "St. Vincent" class. Following about two and a half years' service as engineer officer in the name ship of the class, Admiral Whayman once more came ashore, first to Chatham Dockyard, then on promotion to Engineer Captain in 1917, to Pembroke Dock as chief engineer. In 1918 he became engineer manager at Rosyth Dockyard and during his service there he was awarded the C.B.E. From Rosyth he came south to join the Engineer-in-Chief's Department as Assistant Engineer-in-Chief and in 1922, after two years' service in this post, he was promoted to Rear-Admiral and appointed Deputy Engineer-in-Chief, a position which he continued to hold until his retirement in 1927. In recognition of his services at the Admiralty he was made a C.B. in 1924. After his retirement he continued to be actively engaged in engineering and was for several years marine engineer with Babcock and Wilcox, Ltd. Admiral Whayman was a member of the Institute of Marine Engineers and also of the Institution of Naval Architects, of which he was made an Honorary Vice-President in 1937.

Literature

SHORT NOTICES

This Way Forward. London : Sir Lindsay Parkinson and Co., Ltd., 171, Shaftesbury Avenue, W.C.2.—To commemorate its seventy-fifth anniversary the contracting firm of Sir Lindsay Parkinson and Co., Ltd., has published a book giving, principally, a pictorial account of the major works constructed by the firm during its lifetime. A brief description of the formation and early history of the company is given, and the book also includes a list of examples of the contracts completed by the firm or in progress during the summer of 1954. The firm's larger contracts of recent years have included a great deal of open-cast coal mining (a 25-cubic-yard dragline used for this work is illustrated) ; War Office works and a power station at Dekhelia, Cyprus ; construction of the Esna barrage across the Nile (1944–48), and various large ordnance factory and aerodrome contracts.

Proceedings of a Symposium on Concrete Shell Roof Construction. London : Cement and Concrete Association, 52, Grosvenor Gardens, S.W.1. Price 30s.—The papers and discussion of the 1952 symposium organised by the Cement and Concrete Association have been printed in this volume. The subject is treated under the three general headings of "Architectural Aspects," "Design and Research," and "Construction and Formwork." Apart from the proceedings of the symposium, the volume contains a comprehensive bibliography on all aspects of shell roof theory, design and construction.

BOOKS RECEIVED

Catalysts, Special Compounds and Chemical-Resistant Materials. General editor, E. Molloy. London : George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 21s.

Nigeria Handbook of Commerce and Industry. Published on behalf of the Government of Nigeria by the Department of Commerce and Industries, Lagos. Available from the Crown Agents for Overseas Governments and Administrations, 4, Millbank, London, S.W.1. Price 6s. 8d.

Fatigue Tests on Rolled Alloy Steels Made in Electric and Open-Hearth Furnaces. By P. H. Frith. A report of the British Iron and Steel Research Association. Published in London by the Iron and Steel Institute, 4, Grosvenor Gardens, S.W.1. Price, members 15s., non-members 25s.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

RAILWAYS AND INDUSTRY

SIR,—As a very grateful ex-apprentice to private British locomotive industry and an executive in the mechanical department of British-owned railway companies, I was much interested in your editorial of March 11th, headed "Railways and Industry" and would like to congratulate you on it and on the unanswerable case you make for an alliance between British Railways and the locomotive building industry in developing the diesel locomotive industry to a pitch of efficiency and reliability superior to any in the world. As to the import of diesel locomotives into this country, I agree that to do so on a wide scale would be disastrous for British locomotive prestige at the present time, but once diesel locomotives are operating in quantity in this country there are precedents for the importing of foreign locomotives for comparison and test purposes. I refer, of course, to the import of De Glehn "Atlantic" locomotives by the Great Western Railway in the 1900s.

Although our oldest railway locomotive works, such as Swindon, Crewe, Derby and Gateshead, have constructed locomotives from the earliest times, it is not always remembered that before the grouping of 1923 there were 104 railway companies in this country, of which more than twenty were of considerable size. Locomotive construction, on an appreciable scale, was limited to about seven of these and as the sale of locomotives from one railway to another was forbidden by an Act of Parliament in 1873, the private locomotive industry continued to have a considerable home market until recent years. Such railways as the Cambrian, the North Staffordshire and the Highland Railways seldom, if ever, built their own locomotives and almost invariably relied on the private locomotive industry for their new power. When the grouping took place I have always understood that the locomotive industry was given an assurance by the framers of the Act that a proportion of locomotives would always be bought from the industry and it is only since nationalisation that the fall in locomotive requirements has caused this engagement to lapse.

To me, however, it would appear that the British locomotive industry, despite this assurance, was placed under great disabilities when the railways were grouped as they were no longer able to observe their own designs operating in main line services and thus be able to eliminate any minor faults in design or construction which were revealed by service. You will, of course, understand that this is a most important aspect of the matter as locomotives which go overseas may have teething troubles which, though they are merely annoying to engineers, are sufficient to give them a bad name with railway departments overseas, especially when politics enter into the matter.

Consequently, as the British locomotive industry is entering on a phase of acute competition with foreign locomotive builders, it is very desirable that British locomotives—whatever their size or type of motive power—should not only be of good design and workmanship, as is normal with British locomotives, but should be in a condition which will allow them to go into satisfactory operation immediately on arrival.

This entails close co-operation between all builders and users of locomotives in this country on a scale far transcending anything yet achieved, and British Railways research and testing departments should be glad to co-operate with the private industry in this matter. If this were done it would largely look after types of diesel and electric locomotives of standard gauge intended for export, but where gauges other than 4ft 8½in are concerned some different arrangement is needed. In this particular respect, I understand that the Royal Engineers training centre at Longmoor has a railway which includes a continuous loop of track with few bridges or other obstructions which could be used for testing standard gauge locomotives too high or wide to run on British Railways. Furthermore, at comparatively small expense this loop of track could be made into multiple gauge and thus be suitable for testing any locomotives for export. There seems little doubt that the Royal Engineers would co-operate in this plan with their usual enthusiasm and efficiency and new designs could thus, at comparatively small cost, receive a full running test and be exported in a condition which would raise British locomotive prestige to an even higher point than at present.

The Rugby testing plant was largely the result of Sir Nigel Gresley's advocacy and it is believed that he originally envisaged a test plant which could be used for locomotives of all gauges. Unfortunately, this plan did not materialise and the test plant at present is suited only for standard gauge. It should, however, not be impossible to alter it.

The cost of testing cannot, however, be ignored. Private locomotive builders here are facing severe competition from many foreign builders who are directly or indirectly subsidised by their Governments, and it is hard to expect them to add to their other expenses, even though these charges would not be very heavy, for they would mainly comprise the cost of transporting the locomotives by road or sometimes by rail to Rugby and Longmoor. Is it too much to hope that the Government would co-operate in this expense by debiting one of the existing funds, such as the grant to the National Physical Laboratory. Naturally, only one locomotive of each new class need be tested. The test, however, should be a thorough one to ensure that axle journals are of an adequate size, that bogie frames are sufficiently strong, and that diesel engines, though they may have excellent performances on the bench, are suited to the strains and torsions inseparable from locomotive work. These runs would, therefore, be constituted in order to save time as overseas railways are always in a hurry for their locomotives.

W. FARLEY-NOBLE, M.I.Loco.Engs.

London, W.2.

March 23rd.

REPORTS FROM THE FOOTPLATE

SIR,—Dr. Tuplin cites the article by A. G. Robins, written in 1899, as a pioneering effort in footplate reporting, and as constituting the prototype for the work of subsequent writers. Almost every reader interested in this subject will deplore the monotonous similarity, now current in references (usually meaningless) to "regulator openings," "cut-offs" and pressure gauge readings, &c. The vast majority of such writing lacks real footplate atmosphere and fails to convey any idea of the details of operation or the intimate relationship between men and machine. Reporting of this calibre will, doubtless, continue even after the invasion of electric and diesel propulsion has ousted the beloved "steamer," for as Dr. Tuplin says, there will be even more gauges to watch, then! However that may be, I consider Dr. Tuplin's own article a very notable effort indeed, in this realm of journalism, and I congratulate him on presenting an intensely vivid account of an aspect of locomotive working which, to many without actual experience, will be a revelation.

The occasional footplate traveller usually has an uneventful journey without a serious hitch, from which the impression arises that there is "no more to it" than driving an electric train or even a bus, although few would deny that firing an express engine can be very hard work. It is only under adverse conditions that the skill, resourcefulness and determination of a first-class crew becomes manifest. How easy it would have been for the men concerned in the article to have succumbed to their adversities! The story does, however, illustrate the inherent crudities of the steam locomotive, giving emphasis to a paragraph quoted from the B.T.C. Plan for "Modernisation and Re-equipment of British Railways": "It is also a characteristic of steam operation that it involves hard manual labour for such tasks as firing . . . locomotives. Not only is much of this work unattractive by present-day standards . . . but it also represents an inherently wasteful use of labour."

As we are now witnessing the decline of the steam era, so shall we inevitably see the disappearance of a race of hardy and determined craftsmen and it is timely that some realistic chronicles of their work should be written. How fascinating and instructive it would be if we had such accounts of the vicissitudes of enginemen of bygone days, when both men and engines were driven hard and under conditions of discomfort, which to-day would be intolerable. What, for example, of the exploits and idiosyncracies of the early Webb compounds? In those days, the footplate must have been the setting of many a grim struggle and no doubt railway officials themselves eschewed its attractions! Had it been otherwise, there is little doubt that improvements would not have been so slow.

Finally, some readers may be surprised that Dr. Tuplin's driver had no watch, an adjunct regarded by the layman as the driver's indispensable companion. Last year, when travelling on the footplate of "Eastern Asiatic," hauling the Atlantic Coast Express, the driver occasionally asked me, "How are we doing?", from which I concluded he had no watch. But his manner of asking left me in no doubt that he knew quite well that we were "doing all right," and merely wished to show his prowess, for his timekeeping was exemplary. This is merely a small instance of the part played by intuition or instinct, born of experience in handling probably the most "human" of machines, with all its imperfections, vagaries and its response to coaxing, persuasion and sometimes, punishment!

L. H. LEEDHAM, M.I.Mech.E.

Woking, March 24th.

AUTOMATIC FACTORIES

SIR,—Most people will, I am sure, agree with your excellent article on the subject of automatic factories, particularly your concluding point that, as regards human dignity, they are preferable to mass production factories.

An important aspect, however, that receives scant attention is that an automatic factory with an output, for example, of £1,000,000 a year, will only require a total operating personnel, including maintenance staff, of perhaps twenty-five instead of 500. The cost per unit will not be reduced proportionately, or anything like it, because of the higher capital investment and amortisation. In consequence, there will almost certainly be a reduction in purchasing power distributed by wages because machines do not eat, drink or smoke, and without the ability to consume there is no purpose in producing.

It may also be remembered that, when prices were lowest during the last third of a century, namely, in 1933, world unemployment was highest. Surely there are good reasons for at least as much attention to be given to the economic aspect as to the technical, otherwise the benefits of the latter will not materialise.

ANTONY VICKERS

Isleworth, March 21st.

Plastic Strain and Stress Relations at High Temperatures

By A. E. JOHNSON, D.Sc., M.Sc.Tech., M.I.Mech.E., N. E. FROST, B.Sc., A.M.I.Mech.E., and J. HENDERSON, B.Sc.*

No. III—(*Concluded from page 405, March 25th*)

The work described in this article is a further portion of a general research into the short-time combined stress properties of metallic alloys. It comprises tests made to determine the plastic-strain-stress relations for a 0·17 per cent C steel at 350 deg. and 450 deg. Cent., and an RR59 aluminium alloy at 20 deg., 150 deg. and 200 deg. Cent., under both simple and general complex stress loading conditions. A previous paper (Ref. [1]) dealt with the plastic-strain-stress relations for a magnesium alloy at 20 deg., 50 deg., 100 deg., and 150 deg. Cent. As in the case of the magnesium alloy the intent of the authors has been to explore such a range of plastic strain (1 to 2 per cent maximum) as may reasonably be expected to occur at the commencement of a normal creep test; in this sense the short time investigation is supplementary to a combined stress-creep programme. Only a selection of diagrams of results is reproduced. The full set can be examined by application to the authors.

APPENDIX

It was stated in the text of the report that while the octahedral stress plot was in some cases more closely representative of the experimental results as a whole, this plot was not very markedly superior to the maximum shear stress maximum shear strain plot in this respect. Again, in Figs. 10(*a*) and 10(*b*), and also Fig. 16, the lines corresponding to the Mises isotropic criterion, and the maximum shear stress criterion are shown, and in certain figures some points lie on or quite near the latter. Accordingly, it has been felt by the authors that some consideration should be given to the merits and demerits of not only the maximum shear stress criterion, but the applicability of any mixed criterion in order to compare these fairly with the interpretation advanced in the text. This consideration is made in the following paragraphs.

The Maximum Shear Stress Criterion

A maximum shear stress criterion corresponds with principal strain equations of type

$$\varepsilon_1 = F(\sigma_1 - \sigma_3) \text{ where } F \text{ is a function}$$
$$\varepsilon_2 = -F(\sigma_1 - \sigma_3) \text{ and } \sigma_1 > \sigma_3 > \sigma_2$$
$$\varepsilon_3 = 0.$$

In the case of all groups of tests dealt with in the foregoing text, the 0·17 per cent C steel at 350 deg. and 450 deg. Cent., and the RR59 alloy at 20 deg. 150 deg. and 200 deg. Cent., it is possible to derive from plots of maximum shear stress against octahedral strain, relations of the general form :

$$\varepsilon_1 = A(\sigma_1 - \sigma_2)^n$$
$$\varepsilon_2 = -A(\sigma_1 - \sigma_2)^n$$
$$\varepsilon_3 = 0.$$

A and n having the values in the Table VII shown below. These relations, of course, are only approximate.

Table VII

Material	Temperature deg. Cent.	Value A	Value n
0·17 per cent C steel	350	$9{\cdot}8\times10^{-8}$	4·6
0·17 per cent C steel	450	$2{\cdot}9\times10^{-9}$	5·3
RR59 alloy	20	$2{\cdot}5_8\times10^{-13}$	7·6
RR59 alloy	150	$2{\cdot}4_8\times10^{-14}$	9·5
*RR59 alloy ...	200	$1{\cdot}8_5\times10^{-14}$	10·4

* Very approximate, curve really of double inflexion.

However, the principal strains given by this criterion are in the ratio 1, —1, 0 for all stress systems and temperatures. Tables II to VI‖ give values of the ratio $\varepsilon_1/\varepsilon_2$ (and by comparison with unity of $\varepsilon_3/\varepsilon_1$) computed from the experimentally measured values of axial strain ε_a, and shear strain ε_c, by means of the relations

$$\varepsilon_1 = \varepsilon_a + \frac{\varepsilon_c}{2}\left(\sqrt{(t/2s)^2+1} - t/2s\right)$$
$$\varepsilon_2 = \varepsilon_a - \varepsilon_c/2\left(\sqrt{(t/2s)^2+1} + t/2s\right)$$
$$\varepsilon_3 = \varepsilon_c t/2s - 2\varepsilon_a.$$

These equations were initially put forward by Taylor and Quinney.¶ The accuracy of their prediction has been demonstrated by the authors in tests comparing principal strains in tension and torsion tests computed by these relations, with principal strains measured directly by strain gauges in a series of bi-axial loading tests on plates of corresponding material in which the principal stresses differed only by a hydrostatic stress from those in the above-mentioned tension torsion tests. Virtual identity of values was obtained.** It will be seen from Tables II to VI that the experimentally derived values of principal strains are by no means in the ratio 1, —1, 0 for all stress systems and temperatures. On this account the authors are lead to reject the maximum shear stress criterion.

Mixed Mises and Maximum Shear Stress Criterion

In view of the fact that previous analysis has shown that representation of the data by the Mises criterion alone requires a form corresponding to marked anisotropy, and that the maximum shear stress criterion, while representing the data numerically, nevertheless fails to indicate the presence of anisotropy which the experimental strain ratios show is undoubtedly present, the further step suggests itself of examining the possibility of a mixed criterion of Mises, and maximum shear stress functions applying to the data.

Such a mixed criterion might be framed to lead to principal strain equations of the type,

$$\varepsilon_1 = A[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}[(\sigma_1-\sigma_2)-(\sigma_3-\sigma_1)] + B[\sigma_1-\sigma_2]^{n_2}$$
$$\varepsilon_2 = A[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}[(\sigma_2-\sigma_3)-(\sigma_1-\sigma_2)] - B[\sigma_1-\sigma_2]^{n_2}$$
$$\varepsilon_3 = A[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}[(\sigma_3-\sigma_1)-(\sigma_2-\sigma_3)].$$

Any anisotropy would need to be represented by the Mises terms in these equations, since, in view of their form, it is not possible to do this with the maximum shear stress terms. However, to apply such a mixed criterion it is initially desirable to examine the range of possible application of the criterion. This is easily done by expression of the ratios of axial to shear strain in terms of ratio of tension to shear stress.

Since

$$\varepsilon_1 = \varepsilon_a + \varepsilon_c/2\left(\sqrt{(t/2s)^2+1} - t/2s\right)$$
$$\varepsilon_2 = \varepsilon_a - \varepsilon_c/2\left(\sqrt{(t/2s)^2+1} + t/2s\right)$$
$$\varepsilon_3 = \varepsilon_c t/2s - 2\varepsilon_a$$

we have

$$(\varepsilon_1 - \varepsilon_2) = \varepsilon_c\left(\sqrt{t/2s^2+1}\right) = \frac{\varepsilon_c(\sigma_1-\sigma_2)}{2s},$$

since

$$\frac{\sigma_1}{\sigma_2} = t/2 \pm \sqrt{t^2+4s^2}$$

and

$$\varepsilon_a = -\frac{\varepsilon_3}{2} + \varepsilon_c t/4s$$
$$\frac{\varepsilon_a}{\varepsilon_c} = t/4s - \frac{\varepsilon_3}{4s}\left(\frac{\sigma_1-\sigma_2}{\varepsilon_1-\varepsilon_2}\right).$$

Using the values of ε_1, ε_2 and ε_3 corresponding to the mixed criterion, we have

$$\frac{\varepsilon_a}{\varepsilon_c} = t/4s + \frac{A[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}[(\sigma_1+\sigma_2)(\sigma_1-\sigma_2)]}{4s(A[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}(3)(\sigma_1-\sigma_2)+2B(\sigma_1-\sigma_2)^{n_2})}$$
$$= t/4s + \frac{A[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}(\sigma_1+\sigma_2)}{4s(3A[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}+2B(\sigma_1-\sigma_2)^{\overline{n_2-1}}}$$
$$= t/4s + \frac{A[2t^2+6s^2]^{n_1}(t)}{4s\left[3A(2t^2+6s^2)^{n_1}+2B(t^2+4s^2)^{\frac{n_2-1}{2}}\right]}$$
$$= t/4s + \frac{A[2]^{n_1}[t^2+3s^2]^{n_1}[t/4s]}{\left[3A[2]^{n_1}(t^2+3s^2)^{n_1}+2B(t^2+4s^2)^{\frac{n_2-1}{2}}\right]}.$$

If the Mises term be absent this gives the value $t/4s$. If the maximum shear stress term be absent

$$\frac{\varepsilon_a}{\varepsilon_c} = t/s(1/4+1/12) = t/3s.$$

$t/4s$, of course, corresponds with the normal maximum shear stress criterion applied alone and $t/3s$ to the Mises criterion applied alone. In all other instances the expression gives values intermediate between $t/4s$ and $t/3s$, i.e. the possible applicability of this mixed isotropic criterion is only to such results as lie between the lines of the plot of $\varepsilon_a/\varepsilon_c$ against t/s corresponding to the isotropic Mises and maximum shear stress criteria. Where experimental data lies outside this region such a mixed criterion cannot represent it unless anisotropy be allowed for, and this must be done as indicated previously through the Mises portion of the mixed criterion. In such a case it becomes doubtful whether any extra precision yielded by the mixed criterion in certain regions is worth

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‖ These tables in some cases are abbreviated.

¶ See "The Plastic Deformation of Metals," *Phil. Trans. Royal Soc.*, Vol. 230, page 323 (1932).

** With reference to the above equations, it will be appreciated that if changes of internal volume of a thin-walled tube can be measured either directly or indirectly (by measurement of wall thickness), principal strains can be expressed in terms of strain only. At high temperatures, however, oxidation of the specimen wall makes such measurements impossible. Measurements in vacuum would give rise to a prohibitively difficult experimental technique. Accordingly, the equations shown above, based on the assumption of identity of principal stress and strain axes are used.

the extra complication of the equation.

In what follows each of the groups of tests for the two materials is examined in relation to the possible application of this mixed criterion.

(1) 0·17 *Per Cent C Steel at* 350 *deg. Cent.* (*see Fig.* 10b).—Here the ϵ_a/ϵ_c, t/s plot in Fig. 10*a* indicates that while the three simple loading tests points lie close to the maximum shear stress line, and some of the general loading points at low values of t/s lie between maximum shear stress and Mises lines, the rest of the general loading points of both tests lie completely outside the region between the maximum shear stress and isotropic Mises lines, so much so in fact that a line of mean slope allowing for the points which are between maximum shear stress and Mises still has only a slope of 0·20.

Accordingly on isotropic mixed criterion cannot represent the points in general.

(2) 0·17 *Per Cent C Steel at* 450 *deg. Cent.* (*see Fig.* 10*b*).—Here the two simple loading tests follow the Von Mises criterion, while the other simple loading test lies in between the two criterion lines, but the general loading tests in one case are near to the maximum shear stress, and in the other pursue a zigzag path between the two criterion lines, at higher t/s values moving outside the maximum shear stress criterion line. This is a case where a mixed isotropic criterion might apparently on general grounds reasonably apply. However, further investigation indicates that such a criterion would need to be biased to give results largely in accord with the maximum shear stress criterion at high t/s values.

*RR*59 *Alloy* (*see Fig.* 16).—In the case of this alloy at 20 deg. Cent. one simple loading test lies more or less on the Mises line, a second is rather nearer this than the maximum shear stress. The third simple loading test is, however, well outside the maximum shear stress line, and of the two general loading tests one starts midway between the Mises and maximum shear stress lines, but finishes very greatly outside the maximum shear stress line. The other starts on the maximum shear stress line and again finishes well outside. Accordingly much of the data concerned in this group lies outside the region of applicability of an isotropic mixed criterion.

At 150 deg. Cent. the three simple loading points are well disposed round the maximum shear stress line, one general loading test starts from midway between the two lines and finishes well outside the maximum shear stress line, while the other starts from just below the Mises line and finishes well outside the maximum shear stress line. Accordingly here again an isotropic mixed criterion could not represent the whole of the data.

At 200 deg. Cent. one simple loading test lies on the Mises line and the single general loading test starts from this line. The other two simple loading tests lie well outside the maximum shear stress line, while the general loading test also finishes well outside this line. Here again, therefore, the majority of the data lies outside the range of representation by a mixed isotropic criterion.

To summarise the above facts, in one case only (that of the carbon steel at 450 deg. Cent.) could a mixed Mises maximum shear stress criterion possibly represent the data, and in the case at high values of t/s the criterion must be biased to give results tending to lie in accordance with the maximum shear stress line at high values of t/s. This is, however, the region where maximum anisotropy is indicated by principal strain ratios, which anisotropy cannot adequately be represented by an equation heavily biased in favour of the maximum shear stress terms.

In general, therefore, it seems fair to conclude that if a mixed criterion be used it must be used in an anisotropic form. Since the maximum shear stress part of the corresponding principal strain equations cannot by their nature contribute to the statement of the anisotropy, coefficients describing the anisotropy must be introduced in the Mises terms of the mixed equations. Since the maximum shear stress terms may in these equations be regarded virtually as a bias towards isotropy, any such anisotropy coefficients must be larger than corresponding ones in a purely anisotropic Mises equation, and accordingly a simplification of representation cannot be expected. Add to this the complication of the equations corresponding to the mixed criterion compared with those corresponding to the simple Mises, and it appears that the authors are justified in concluding that Mises equations allowing for anisotropy are the best form of representation of these results.

Conclusions

(1) While deformation equations of stress plastic strain cannot be strictly applied to general loading tests, the results of the present series of tests on both materials at all temperatures indicate that the results derived from the use of such deformation equations agree within the limits of reproducibility of individual tests with the experimental values obtained. This is of practical importance, since deformation type equations are obviously very much easier to use in design.

The general form of the principal strain stress relations of deformation type is

$$\epsilon_1 = A_1[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}[(\sigma_1-\sigma_2)-(\sigma_2-\sigma_3)]$$
$$\epsilon_2 = A_1[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}[B(\sigma_2-\sigma_3)-(\sigma_3-\sigma_1)]$$
$$\epsilon_3 = A_1[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}[(\sigma_3-\sigma_1)-B(\sigma_2-\sigma_3)]$$

where B is an anisotropy coefficient. Anisotropy in the great majority of the tests is displayed virtually from the commencement of the plastic strain to the end of the test.

(2) In the case of the 0·17 per cent C steel at 350 deg. Cent. and 450 deg. Cent., and under both simple and general loading conditions, ϵ_a/ϵ_c (where ϵ_a=axial plastic strain, ϵ_c=shear plastic strain) appears to vary linearly with the ratio of axial stress to shear stress. In the case of the RR59 aluminium alloy at 20 deg., 150 deg., and 200 deg. Cent. the same remarks apply to the simple loading tests, but in the general loading tests ϵ_a/ϵ_c assumes a value at the commencement of plastic strain which is then maintained throughout the test.

(3) For both materials at all temperatures the maximum principal strains for both simple and general loading may be computed directly from pure tensile or pure torsion tests.

(4) For the 0·17 per cent C steel the degree of anisotropy occurring, and the distribution of strain between the two secondary directions for general loading conditions may be computed directly from simple loading tests; in the case of RR59 alloy this is apparently not so.

(5) The criterion of the limit of elasticity for the two materials at the temperatures concerned appears to lie between maximum shear stress and shear strain energy, with a bias in most cases in favour of the latter.

Electromagnetic Coupling Alternators for Cargo Ship "Golden Bay"

THE 1400-ton motor ship "Golden Bay," which is described on page 448 of this issue, is a bulk cargo ship equipped with electrically-driven, self-discharging cargo-handling machinery. In a ship of this class and size, the electric power requirement in harbour may be of the same order as that needed for propulsion at sea. To provide this power by orthodox means would have involved the installation of auxiliary generating sets of about the same size as the propulsion machinery—an uneconomic use of space, particularly in a small ship.

For this kind of duty, the British Thomson-Houston Company, Ltd., has, therefore, made further developments to the conventional electromagnetic coupling so that, besides operating as a normal coupling between the main engine and the propeller when the ship is at sea, it can also be used as an alternator, driven by the main engine, for supplying electric power when the ship is in port.

The motor ship "Golden Bay," the first ship to be equipped with these electromagnetic coupling alternators, was built by Henry Robb, Ltd., for the Tarakohe Shipping Company, Wellington, New Zealand, in conjunction with the Golden Bay Cement Company. The ship is designed for carrying cement or coal in bulk,

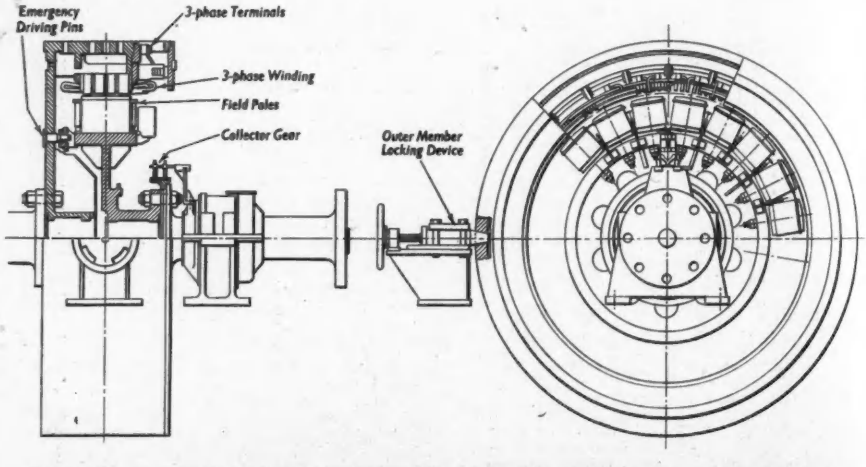


Fig. 1—Electromagnetic coupling alternator for ships. At sea this machine serves as a coupling in the propulsion system; in port it is run as an alternator

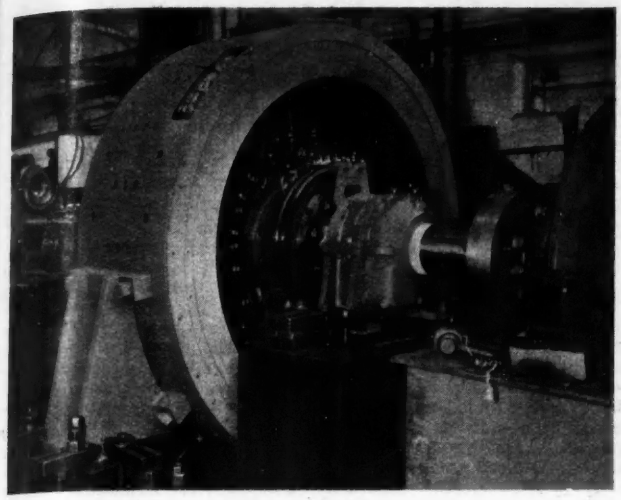


Fig. 2—One of the two coupling alternator sets for the motor ship "Golden Bay," on test at the maker's works, Rugby

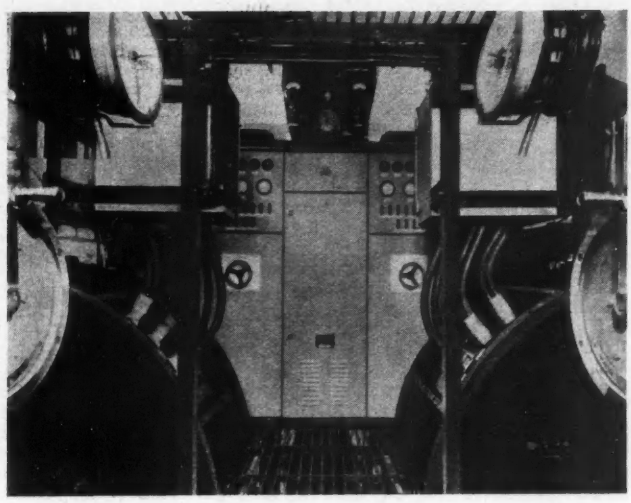


Fig. 3—Electromagnetic coupling alternators and control panel on the motor ship "Golden Bay," looking aft

and is powered by two British Polar "M44M" diesel engines, each developing 630 b.h.p., transmitting power at 250 r.p.m., through an electromagnetic coupling alternator, giving a service speed of 10 knots.

Each coupling alternator unit (Figs. 1 and 2) consists of an inner member and an outer member without any mechanical connections between them. The inner member is coupled to the engine crankshaft through an intermediate stub shaft and sleeve bearing, which ensures that the weight of the member is not wholly carried by the engine crankshaft. The outer member is coupled directly to the propeller shafting.

The inner member consists of a fabricated steel rim, on which are mounted twenty electromagnetic poles facing radially outwards. This rim is mounted on a fabricated steel spider, with spigotted flange for bolting to the intermediate stub shaft which, in turn, is coupled to the engine crankshaft. Excitation is supplied from the ship's auxiliary 220V d.c. busbars through sliprings mounted on the coupling flange, the necessary brushgear being mounted on a bracket attached to the intermediate bearing pedestal.

The outer member consists of a fabricated disc and a steel outer rim carrying the laminations and a three-phase winding for the rotating field system on the inside of the rim. The windings consist of copper bars assembled in the slots of the laminated core and have Class B insulation suitably impregnated to withstand tropical marine engine-room conditions. The winding is star-connected, and, while the units are being used as couplings, the phases are connected together to form a closed circuit acting as a squirrel-cage winding. Under this condition, power is transmitted from the engines to the propeller shafts with only a small reduction in speed, corresponding to the slip of the coupling, which is about 1½ per cent.

When in harbour and being used as alternators, the outer members are locked stationary by means of a steel wedge which engages in a slot in the rim of the outer member. The short-circuiting links are removed and suitable connections are made to the three-phase windings of each outer member; the units can then be used as conventional alternators each driven by one of the main engines. Under such conditions the engines are run at 300 r.p.m., and the alternators develop 500kW each, at 440V, three-phase, 50 c/s, this frequency being chosen to permit standard a.c. marine motors to be used for the cargo handling drives.

The control panel for the coupling alternators (Fig. 3) is of the dead-front pattern, with provision for individual control of each coupling. Control rheostats and the necessary lamps and meters for use with the coupling alternator units are mounted on the panel. Indicating lamps are provided to show when the 220V d.c. is connected to the panel, and a green lamp indicates when excitation is applied to the coupling-alternator; earth lamps are also provided. A field ammeter is fitted, as well as a voltmeter and ammeter for indicating the output voltage and current of each coupling alternator unit.

The field excitation of the coupling-alternator units is controlled by a handwheel with star wheel location for the initial step. Moving the handwheel to this position closes mechanically-operated contactors by means of cams and applies excitation to the coupling. Further rotation in a clockwise direction increases the excitation. As these coupling-alternators are not designed for manoeuvring (all manoeuvring being carried out on the engines), the excitation must be applied before starting up the engines, and interlocks are fitted on the engine controls to operate audible alarms should the excitation be applied with the engines running.

When the machines are operating as alternators, their output voltage is maintained between preset limits, irrespective of the total load, by connecting or disconnecting fixed steps of resistance in series with the alternator fields. These resistances are switched in or out of circuit by contactors operated by relays supplied from current transformers.

As the load current increases, the relays operate at predetermined current values and cut out the fixed steps of resistance to increase the excitation. Three such steps are provided, and by this means the voltage is maintained between the safe operating limits, final adjustment to 440V being made when the load has reached a steady value.

This panel also accommodates the circuit-breakers and bus-section switch for supplying power from the alternators to the a.c. distribution boards.

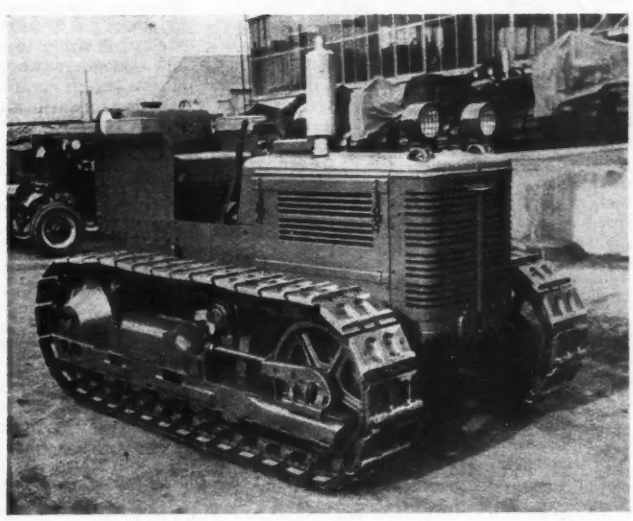
No provision is made for paralleling the alternators, but the bus-section switch enables one alternator to feed both distribution boards, allowing unloading to be carried out at a reduced rate, using one engine only, if the other should be out of commission for overhaul. The circuit-breakers and bus-section switch are interlocked with Castel key exchange to prevent paralleling of the alternators.

Auxiliary 220V d.c. power is supplied by two 60/70kW and one 30kW B.T.H. generators, driven by Russell, Newbery engines.

Most of the drives for the ship's cargo handling machinery are supplied directly from the coupling alternator sets at 440V, three-phase, 50 c/s. Drives requiring individual speed control, however, are supplied by 220V d.c. Ward-Leonard generators driven by a 200 h.p. squirrel-cage motor; these drives include the 5 h.p. travel motions of the two travelling unloaders which serve the two holds, and the four 35 h.p. longitudinal conveyors, two in each hold.

50 H.P. Crawler Tractor

A CRAWLER tractor with a diesel engine which develops 50·5 b.h.p. is the latest product of International Harvester Company of Great Britain, Ltd., 259, City Road, London, E.C.1. It has been styled the "New BTD–6," as apart from its greater weight and power it is very similar in design to the 40 b.h.p. crawler tractor which the company introduced about two years ago. For the production of that tractor at its Doncaster works, the company found it necessary to import some components, notably parts of the gearing, from the U.S.A. In the last eighteen months, however, these imports have steadily dwindled as new additional machine tools have been installed at Doncaster. In the foundry, also, new equipment has come into operation with the result that both the existing 40 b.h.p. and the new 50 b.h.p. "BTD–6" tractors are now all-British products.



Crawler tractor fitted with four-cylinder diesel engine developing 50.5 b.h.p. at a governed speed of 1450 r.p.m. The extended track frame shown here employs five rollers

The new tractor is illustrated on this page.

Its power is provided by an "International" four-cylinder diesel engine, 4in bore by 5½in stroke, which has a rated governed speed of 1450 r.p.m. Transmission is through a single-plate, 13in diameter clutch, and the spiral bevel gearing has been redesigned to give a smoother transfer of power in the tractor. In the final drive assemblies the length of tooth of the spur and bull gears has been increased by 25 per cent compared with the 40 b.h.p. tractor. The new tractor has five forward speeds between 1·5 and 5·4 m.p.h., and a reverse speed of 1·7 m.p.h. Special equipment which can be incorporated in the tractor includes a six-spline power take-off shaft, giving 862 r.p.m. at rated engine speed and a 12½in by 8½in belt pulley designed for 811 r.p.m. at rated engine speed. The regular track equipment consists of a four-roller frame with an equaliser spring mounting, though a similar frame employing five rollers is also being made available. The principal track dimensions

Hydraulically operated shovel. The bucket has a capacity of 1¼ cubic yards, the loading height to the hinge pin being 9ft 11in. The overall width of the shovel is 5ft 8in

are 50in from centre to centre of tracks, the length of the tracks on the ground being 58⅝in. There are thirty-two track shoes on each side, the standard shoe width being 14in. The area of ground contact is 1641 square inches, and the ground pressure, based on the operating weight of the tractor, is 5·54 lb per square inch. The makers say that, at the rated governed engine speed of 1450 r.p.m., the tractor, when in first gear, gives a drawbar pull of 10,500 lb.

As illustrated, the tractor is fitted with a five-roller track frame, instead of the normal four-roller equipment. The makers have taken this step bearing in mind the industrial, as distinct from the agricultural employment of the tractor. Coincident with the introduction of the new tractor, International Harvester Company of Great Britain, Ltd., has begun production at Doncaster of the "Drott" skid shovel, which has hitherto been manufactured in the U.S.A. A photograph of this equipment assembled on a tractor is reproduced herewith. The mounting brackets, as well as the hydraulic tank and valves are placed at the back of the tractor to assist the stability of the shovel, the normal equipment of which includes a "light materials" bucket of 1¼ cubic yards capacity. Other available attachments include a ⅞ cubic yard rock shovel and a dozer blade. The operating mechanism incorporates a "hydro-spring" consisting of a hydraulic cylinder enclosed in a coil spring. The makers point out that any shock force opposing the force of the hydraulic system tends to displace oil from the hydraulic lift cylinders. This displaced oil is channelled into the "hydro-spring" cylinder, so that the cylinder is extended and the coil spring compressed, an action by which the initial shock is absorbed. The loading height of the shovel illustrated is 9ft 11in to the bucket hinge pin, and it can dig below ground to a depth of 11in. The maximum dumping angle is 62 deg. and the overall width of the shovel is 5ft 8in.

Terminal Buildings at London Airport

No. I

Certain terminal buildings will be commissioned this month at London Airport. They include the control tower in which is based an unusually comprehensive system of surveillance and navigational aids, and passenger and luggage handling buildings, housing recently developed equipment. We begin a description of these facilities, with a brief account of the routing and landing techniques, which will be adopted at the airport.

THE first of London Airport Central's new group of modern terminal buildings, covering 158 acres in a diamond-shaped area, comes into use for air traffic control on April 3, 1955. The terminal area occupies an island site in the middle of the aerodrome, separated from the perimeter and the main Bath road by runways and taxiways, but connected with the Bath road by a 680 yard tunnel running beneath the runways. The buildings, which will gradually replace the temporary buildings along the Bath road, are set in a carefully planned pattern in which roads, car parks, aircraft stands and the whole range of services required for a modern airport have their place.

British European Airways, and the foreign short-haul operators now in the Bath road area, will move into the new building on the south-east face of the diamond, for the service of passengers, on April 17th, and by the end of the year, another building of unusual design on the eastern apex of the diamond will be ready. This will complete the first phase of the plan. Later on there will be a freight building, and the last phase of the present plan will be completed by about 1959 when British Overseas Airways Corporation and the long-haul operators will move over from the Bath road terminal to a passenger building.

In point of architecture and interior decoration and equipment, London Airport Central has been planned on an impressive scale and to a standard to match its importance as one of the greatest centres of international air traffic in the world, and it is equipped to provide a correspondingly high standard of service and amenity for passengers and for the public generally.

Aircraft flying to and from London Airport and all movement on runways, taxiways and aprons will be controlled from the tower, which is planned as a focal point of a highly complex system of radio and line communication, radio and radar navigational aids, airfield lighting, and ground movement control.

Interesting features of the south-east face passenger building, which will not be completely finished until September next, are the streamlining of passenger handling through the controls; mechanical handling of baggage on conveyor belts, which present it to the customs hall, and then, out of sight, carry it to the landside or airside as required; and the roof gardens, with their restaurants and amenities for spectators. A third building of segmental shape, providing accommodation for the administrative offices of airline operators and a number of public amenities including a new cinema, post office and an additional restaurant and grill room overlooking the apron, is under construction, and will be completed at the end of this year.

The aprons in London Airport Central will be served by inner taxiways, which run through the centre and lead to aircraft stands on each side. Passengers will reach the furthest aircraft stands in buses going through subways under the aprons. The route to the central terminal area from the Bath Road and all parts of the airport is through the main tunnel. The tunnel has a dual carriageway and separate provision for cyclists and pedestrians.

Control Building

The control tower rises 127ft from the heart of the Central Terminal building, which is arranged in a "T"-shaped plan, with the tower at its fulcrum. Staff restaurants are grouped, with the kitchen, in the leg of the "T" to the south side. The west wing contains administrative offices on the first floor and a medical centre on the ground floor, part of which will be fully equipped as an emergency casualty clearing station. The tower has nine floors, of which air traffic control occupies the top four.

Aerodrome control and ground movement control are in a glass-walled and glass-roofed penthouse at the top of the tower, giving the controllers a panoramic view of the whole airport and the sky above. Immediately below, approach control is located in a lofty room, which is cantilevered out beyond the face of the tower, and enclosed by sloping glass on three sides.

Ground Movement Control.—Movements of aircraft and vehicles on the airport—except on the runways in use—are the responsibility of the ground controller in the glass penthouse, who is provided with a small-scale model of the lighting system of runways and taxiways; selects the route for the pilot or vehicle driver to follow and switches on the appropriate lights. Simultaneously, the selected route lights up on the model.

Routes are marked at night by green lights flush with the ground in the centre of the taxiway, and in daylight by illuminated route indicators at the side of the taxiway. If the ground controller wishes to stop any aircraft or vehicle at night, he switches on a stop bar of red lights across the runway, and by day a red traffic light on the route indicator. The "mimic" display tells the controller at a glance which lights he has switched on. He can thus keep a visual check on surface traffic movements in all but the worst weather.

In bad visibility, the controller watches these movements on a millimetric radar set, called an airfield surface movement indicator, which provides a complete picture of traffic on the runways and taxiways. At the same time, the controller is in constant touch by radio-telephone with all vehicles and aircraft under his control. Pilots can check their position from numbered boards placed at the end of each section of the taxiway and report to control. The same applies to drivers of vehicles. Aircraft about to take off are the responsibility of the air controller, who is assisted by a radar controller, who can watch aircraft for a short while after they are airborne, and by knowing their exact position, the air controller can dispatch successive aircraft with a minimum of delay.

Approach Control.—The approach control room on the sixth floor is large enough to cope with any expansion of traffic or with improved techniques of air traffic control, and it has been planned around the radar equipment. There are two radar controllers in the approach control room—one guides aircraft from a radio fix at Epsom and directs them on to the approach path to the runway, the other guides aircraft from a radio fix at Watford and directs them at safe intervals on to the same approach path. In this way, in bad weather, aircraft can be landed at the rate of about twenty an hour.

About 6 or 7 miles from the runway, the radar controllers in approach control hand over the aircraft to the talk-down controller, who directs or monitors the aircraft to a position from which a landing can be made. The talk-down controller is at present housed in a caravan near the runway, but later he will be placed next to the radar controller in the tower.

Bad Weather Procedures

The following description of the procedures followed by departing and arriving aircraft relates to instrument flight rule weather conditions in which full use is made of all the air

traffic control facilities. Thirty minutes before an aircraft is due to leave the pilot fills in a flight plan form showing his destination, the estimated time of arrival, the altitude at which he wishes to fly and other relevant details. This plan is handed in at one of the two air traffic control clearance offices, and details of the plan are telephoned to the Southern Air Traffic Control Centre departure sector and by pneumatic tube or telephone to the ground controller in aerodrome control.

When the aircraft is ready to go the pilot calls the ground controller by R/T and asks for permission to taxi out. The ground controller tells the pilot the runway in use and gives him the route to follow to get to it. A lighting and route controller switches on the daylight route indicators (by day) or green centre-line lighting (by night) on the selected route and the ground controller checks that this has been done correctly by reference to the mimic of the aerodrome lighting. While the aircraft is taxying out the departure and clearance co-ordinator, who is also in aerodrome control, receives from the departure sector at the Southern Air Traffic Control Centre an airways clearance for the aircraft. This clearance will give the route the aircraft must follow after the take-off, the altitude at which it must fly and other instructions.

After take-off the time of departure is telephoned to the air traffic control clearance office. The air traffic control assistant fills in the departure time on the flight plan, which is then sent by the teleprinter office to all air traffic control authorities concerned with the flight.

Arriving Aircraft.—Until recently aircraft going to London Airport were routed to the radio range station at Epsom and from there were fed under radar surveillance and direction into the airport. This system gave a landing rate of fifteen to twenty aircraft per hour. At peak periods arrivals at London Airport may be well in excess of that rate. To deal with this, a system known as " twin stack feed " has been introduced. It is hoped to increase the rate initially to a minimum of twenty-five to thirty per hour. With this system aircraft bound for London Airport are routed not only to the Epsom radio range but also to the Watford radio range ; from these points the flight paths of the aircraft are adjusted under radar direction so that they are positioned on the final approach path with the minimum permissible separation between them.

Twin Stack Feed and Approach Phase.—If two aircraft are approaching a common point, the approach to the runway, from two positions which are widely separated (Epsom and Watford) the radar controller so arranges their paths and the times at which they leave the stacks that the distance between them when they reach the approach to the runway is sufficient for safety and sufficient to ensure that the second aircraft will not reach the runway approach before the first aircraft has cleared the runway. If all aircraft flew at the same speed, if there was no wind and if aircraft left the range stations at exactly the time and place instructed, the problem would be simple. No satisfactory computer is yet available and this co-ordination depends on the skill and experience of the radar controller. As it is, none of these provisos is normally met.

Talk-down Phase.—On the final approach, the length of time required for a G.C.A. talk-down is about three minutes. If every aircraft carried out the full G.C.A. talk-down procedure the landing rate could not be better than twenty per hour, as one talk-down controller cannot handle more than one aircraft at a time. Alternative solutions would be to duplicate the G.C.A. equipment or to reduce the distance at which the talk-down is commenced. The latter solution would throw an unacceptable work load on to the other radar controllers ; the former could only be introduced by duplicating the G.C.A. equipment and employing extra talk-down controllers. New equipment should be available with which two or more aircraft at a time may be handled. In the meanwhile, however, the most promising solution is to dispense with the full talk-down and, instead, to encourage pilots to land using the I.L.S. This is airborne beam riding equipment and because it places a greater demand on a pilot's blind flying capacity, the number of overshoots increases and if radar is not used as well during the final approach phase the separation required between successive aircraft would have to be increased. If, however, the I.L.S. approach is " monitored " by the talk-down controller on his radar screen, the best advantage is taken of both systems and a higher approach rate can be achieved.

Landing Phase.—The limitation imposed by the time taken for a landing aircraft to clear the runway should not prove a serious problem until the landing interval decreases to about two minutes. Nevertheless, every effort is being made to get aircraft off the runways as quickly as possible. The most promising method of achieving this is the use of high-speed turn-offs, i.e. taxi routes off the runway at a fairly shallow angle so that aircraft can take them at speeds of the order of 30 to 40 knots.

The development of the procedures for radar sequencing have been dealt with at some length, since it is in this sphere that the most important changes are taking place at London Airport. The following paragraphs describe the progress of an arriving aircraft, assuming that the weather is bad, that Runway 28L is in use and that the aircraft is approaching via the Epsom radio range.

Landing Sequence.—As the pilot approaches the range station, he communicates on R/T with the London Airport approach controller responsible for movements through Epsom. The controller will tell the pilot which runway is in use and will give him details of the weather at the airport. The track of the aircraft and its altitude will be adjusted as necessary by the radar approach controller, so that it arrives, pointing at the aerodrome, at a position about 7 miles from the runway at an altitude of 1500ft and so that it is correctly spaced behind the aircraft ahead of it. When it is necessary for a controller to identify a particular aircraft from a number appearing on his tube, he uses a direction finding equipment, the AD210, which indicates with great accuracy the bearing of any aircraft calling the controller on R/T.

Situation of Precision Radar.—Ideally, the talk-down controller should be positioned next to the radar approach controllers, so that the hand-over of control may easily be made. However, until further development work is complete this will not be possible and for the present the talk-down controller must remain in the G.C.A. truck, out on the airport near the runway in use. The hand-over of the aircraft is therefore made by telephone from the radar approach controller to the talk-down controller. The talk-down controller guides the aircraft from the 7-mile position to a point 400 yards from the end of the runway, from which position the landing is completed visually by the pilot.

When a landing aircraft has touched down and is on the runway, the talk-down controller can no longer see it. Eventually, when the talk-down controller is in approach control, he will be equipped with an airfield surface movement indicator radar of his own and, provided the runway is being used only for landings, he will be able to see for himself when the runway is clear and will not need clearance from the air controller. As in the case of departing aircraft, the lighting and route controller will switch on the daylight route indicators or the green centre-line lighting as necessary.

(To be continued)

INDICATING MICROMETER.—A micrometer of German manufacture now being distributed in this country by Production Promotion, 94, Camden Road, London, N.W.1, has a window in its barrel through which are exposed numbers corresponding to the usual lineal graduations. Each 0·001in graduation on the barrel has a corresponding number which appears in the window as the barrel is turned. With these numbers, it is pointed out, the possibility of error in taking a reading is reduced as there is no necessity to count lines, and readings can be taken more quickly and easily. A normal vernier scale is provided for reading to 0·0001in, and these graduations are easily read as they are widely spaced on the ¾in diameter barrel of the instrument. The micrometers are finished in dull chrome, and a knurled plastic sleeve at the top of the barrel gives a good finger and thumb grip.

Improvements in the Performance of Steam Pumping Plant

SOME interesting work involving modifications to the Cambridge water undertaking's steam pumping plant at Fleam Dyke pumping station was discussed at a meeting of the south-eastern section of the Institution of Water Engineers last week. Abstracts from the paper* describing this work are given here. Fleam Dyke pumping station was designed in about 1912, and the plant installed there consists of two independent but similar horizontal tandem compound steam engines of about 200 h.p.; each has dimensions of 23in plus 51in by 48in, and drives, by backward extension of the piston-rod, first, a double-acting piston force pump, and, second, a pair of single-acting well pumps operated by opposed quadrants. For some time prior to the modifications, the plant had been methodically overhauled to give better running and performance, but it was considered that still better results could be achieved. The proposed modifications were therefore first drawn up from data from thermal efficiency trials by the author, and Mr. H. R. Lupton was consulted and prepared a report on the scheme. In fact, the modifications were carried out at a cost of £9700, and it is calculated that annual savings of £2390 will result.

So as to improve the dryness of the steam as it passed through the engine, three modifications were carried out, namely, higher initial superheat, steam jacketing of cylinder, and reheat. The initial steam temperature was limited to 750 deg. Fah., because of low load on the boiler, such that the temperature of the gases in the downtake was not expected to be much above 1000 deg. Fah., and because expensive heat-resisting pipework was not necessary at that temperature. The design of the reheater was based on a steam inlet temperature of 750 deg. Fah. and an outlet temperature of 600 deg. Fah., the latter being fixed at the highest degree possible consistent with lubrication of the h.p. Corliss valve of the engine. A saving of 19 per cent in the heat consumption of the engine was estimated from these modifications.

The next economy involved the provision of mechanical stokers, which would save about £425 per annum in wages (only one " spare " man would be needed at the station instead of two), and give a small fuel saving, but cost about £40 per year for power, assuming an electrical drive.

A direct drive provided for the boiler feed pump gave an estimated saving of 4·5 per cent in steam consumption. Adjustment of the force pump discharge gave a further estimated saving of 3·0 per cent, as there had been an excess of discharge of the well pump over that of the force pump, which had previously been returned to the well. Availability of the plant was improved by modifying the main pedestal bearing, high-tensile steel bolts being provided to reduce movement.

The principal savings are listed, as they were actually effected, as follows :—Increased superheat, jackets and reheat, 19 per cent ; mechanical stokers, plus gain due to larger superheaters and improved heat insulation, 8·1 per cent ; direct drive of boiler feed pump, 3·28 per cent ; increased force pump discharge, 1·90 per cent ; total, 32·28 per cent. The savings result from a saving of 570 tons of coal annually, and £425 in wages.

About 1200 m.g. of water is pumped annually by the plant, and the overall plant performance when the modifications were completed is given as about 0·9 m.g. pumped per ton of coal consumed. The overall thermal efficiencies of boiler, engine and pumps on discharge (w.h.p./heat input to boiler) is given as 7·3 and 7·1 per cent respectively before modification with and without vacuum jackets, and as 11·0 per cent after modification. The steam consumptions before and after modification were respectively 18·8 and 13·7 (pounds per w.h.p.-hour) and the coal consumptions 2·75 and 1·73 (pounds per w.h.p.-hour).

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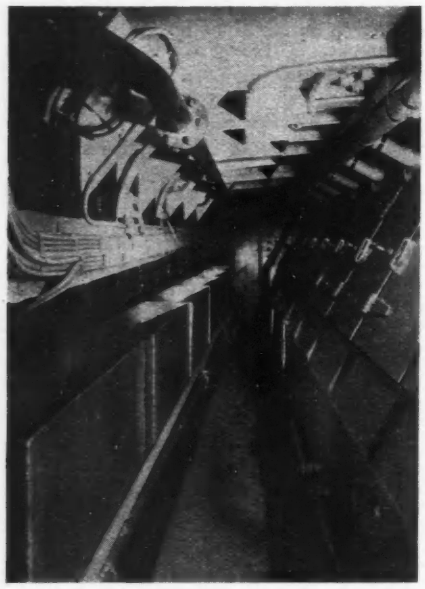
* " Modifications at Fleam Dyke Pumping Station, Cambridge University and Town Waterworks Company," by W. Grant Gibson. This paper is published in the March issue of the *Journal of the Institution of Water Engineers.*

Equipment for Experimental Freezing at Sea

THE economics of operating the fishing industry, and more particularly that part of the fleet concerned with distant water trawling, are affected by a number of factors including the correlating of supply and demand, and the disposal of that part of the catch surplus to market capacity. When fishing is at its peak, during the spring and summer, much of the catch remains unsold and has to be disposed to fish meal works at a loss. Any such loss assumes considerable magnitude when the size of the distant water fleet is considered, a fleet which consists of about 300 trawlers ranging from 140ft to 190ft in length. The problem has been the subject of study by the Distant Water Vessel Owners' Development Committee, which has evolved a scheme for the freezing at sea of the earlier part of the catch. About two years ago the White Fish Authority accepted the proposal and it was agreed that the cost of the experiment, to be carried out on a commercial scale, should be borne by the Authority, H.M. Government and the distant water trawler owners. A joint committee co-ordinated and supervised the preliminary work and the Torry Research Station of the Department of Scientific and Industrial Research developed special freezing equipment, for which, after tests, orders were placed, together with those for ancillary gear. Last year the trawler "Northern Wave" was chartered for the purpose of the experiment and has been converted and fitted out with the new equipment.

It is hoped that the experiment will provide the answer to several questions which have a bearing upon the economic working of the fleet which



Loading passage showing the doors to freezer, control lever and fish bins

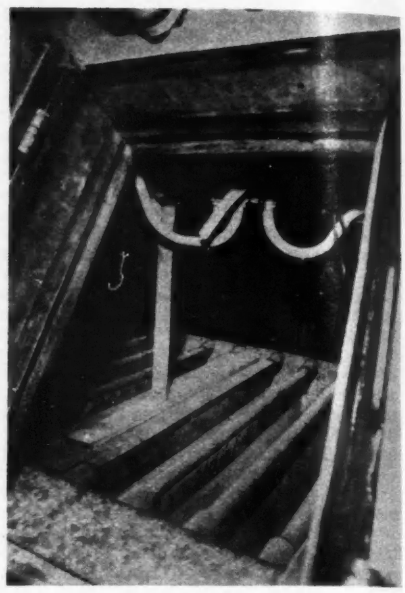
fishes off Iceland, Greenland, Northern Norway, Bear Island and in the Barents Sea. With grounds up to 1500 miles from port the ships may spend three weeks at sea, of which only one is occupied in fishing. Although the freezing equipment would add to existing costs, the experiment, if successful, should enable the ship to increase the proportion of time spent on the fishing grounds in relation to the time spent steaming out and home. Again, the surpluses usually sold at low price will be replaced by quick-frozen fish of higher market value. It is expected that the trial period to assess costs and the potential advantages will last for about one year.

For the purposes of the experiment the quick-freezing plant has been designed with a capacity of 5 cwt of fish per hour and is expected to freeze about 5000 stones of fish each voyage. This quantity represents approximately one-fifth of the total average catch, the remainder being stored in ice in the usual manner. Cod is the fish mostly caught and the design of freezer adopted is based upon a successful pilot scale vertical plate unit developed at the Torry Research Station. J. and E. Hall, Ltd., has manufactured the two freezers, fitted in the ship, each of which consists of four cabinets divided into half-cabinets, each half-cabinet having a separate loading door. The doors to the starboard freezer are of light-weight construction, of "Fibreglass" reinforced at hinges and bolts, while the port unit has doors of wood with aluminium alloy panels. Each of the sixteen half-cabinets are subdivided into three spaces by vertical metal plates which are made in two parts, each part consisting of a plate into which grooves have been pressed so that when assembled gas passages are formed. The plates are hung from a gas header and at the point of attachment special sealing rings are used and packed with low temperature grease, so that the joint is flexible and each plate is free to move. A door which is hinged to open downwards in a fore and aft direction forms the bottom of each half-cabinet, while another door hinged at the top forms the inboard side. One of our illustrations shows the loading arrangements, including the doors to the freezer, operating levers and fish bins, while the other gives an interior view of the freezer.

The trawler "Northern Wave," chartered for the experiment, has a length of 188ft by 28ft beam by 16ft depth and was built in 1937 in Germany. Conversion work, which was carried out by the Humber St. Andrew's Engineering Company, Ltd., involved extensive alterations, including the building of a cold store at the forward end of the existing fish hold, the installation of two freezers and the refrigerating machinery. The equivalent of 500 kitts can be stacked in the cold store and the remaining part of the original hold has a capacity for 2500 kitts of wet fish. Some unusual structural problems had to be overcome, including the replacement of parts of the steelwork which pierced the insulation, by reinforced plastic members of lower heat conductivity. This precaution was necessary in order to reduce to a minimum the heat entering the cold store in order to prevent the drying-out of the frozen fish. Outside the cold store are loading passages, to port and starboard, with access doors from the fish hold and the refrigerating machinery space, while the two freezers are placed fore and aft within the cold store with loading doors opening out into the passages.

Orthodox refrigerating machinery has been fitted and the units have been installed in a compartment which is immediately forward of the cold store and which was formerly part of the net store. There are two 7¾in by 6in twin cylinder, single stage compressors driven at 450 r.p.m. by a 25 h.p. motor to serve the freezers and two 4in by 3½in compressors, one of which is a duplicate, driven at 500 r.p.m. by an 8 h.p. motor for the cold store grids. All the circuits are of the direct expansion pattern, working on Arcton 6. In the refrigerating machinery space recording gear has been installed to record ambient air temperature and the temperature at various points throughout the cold store. To meet the increased demands for the electrical power required to drive the freezing installation space had to be found to fit new generators in the engine-room. Power for the freezers is provided by a 48kW generator driven by a Belliss and Morcom steam engine, and a 17·5kW diesel-driven generator supplies the ship's auxiliaries and cold store, while there is a 48kW stand-by diesel-driven generator. Both the diesel generators are powered by Ruston and Hornsby engines. To provide more steam the Scotch boiler which burned oil fuel under natural draught on the White system, has been converted to forced draught and a Howden's steam-driven fan has been installed. Nicolam, Ltd., manufactured the plastic components and the J. D. Insulation Company, Ltd., supplied the insulation.

With the ship on the fishing grounds and the plant in operation the catch will be prepared in the normal way, gutted and washed, and then put into the wet fish hold ready for loading into aluminium bins which are placed in a rack fitted along the ship's side in the freezer loading flat. Any fish in excess of loading capacity will be stored temporarily in ice. From the bins the fish is placed head to tail in the spaces between the vertical plates in the freezers and then



Interior of freezer showing vertical plate divisions and gas headers

refrigerated at minus 35 deg. Fah. into slabs measuring about 36in by 18in by 4½in and weighing approximately 60 lb. This operation, which is timed by a clock placed above each half-cabinet, takes about four and a half to five hours and when complete the movement of a single lever at each half-cabinet, and operated from the loading passage, serves to operate wedges to spring open the bottom and side doors from the ice and to open out the vertical plates by giving a graduated and limited movement to the lower edges. Simultaneously, the operation of special changeover valves causes a reversal from cold to hot refrigerant gas, the flow of hot gas lasting for about thirty seconds, to warm the plates and assist in the release of the slabs of fish. The slabs drop into a net and are then stacked in the cold store which is refrigerated by pipe grids at minus 20 deg. Fah.

Agricultural Tractor Developments in Kenya and Southern Rhodesia

INTERESTING recent developments of enterprises initiated by the Massey-Harris-Ferguson Company are reported, and relate, in the first place, to activities in Kenya. There, most of the farming land lies well above the 5000ft level and the company's experts have been investigating power losses in internal combustion engines associated with increases in altitude. The average loss is 4 per cent for every 1000ft above sea level, and experiments with Ferguson tractors have been carried out with superchargers fitted, and it is reported that of the several methods of improving the power output none but supercharging give very encouraging results.

Plans in Southern Rhodesia, are being made for an intensive educational campaign to assist and advise tractor owners throughout the country.

Proving the Performance of Circuit Breakers*

By J. CHRISTIE, M.I.Mech.E., M.I.E.E., H. LEYBURN, B.Sc. (Eng.), M.I.E.E., and J. F. BIRD, M.C., B.Sc., A.M.I.E.E.†

No. II—(*Concluded from page 426, March 25th*)

The characteristics of the main types of circuit breaker are briefly summarised, and the various aspects of test-circuit severity are considered, both in relation to actual service conditions and to their effects upon the different types of circuit breaker. Existing test procedures and methods are reviewed, and suggestions are made for the improvement of some of them and for their being brought more into line with present service requirements. Proposals are also made for methods of approach to certain tests which it has not yet been possible to standardise. Particular attention is paid throughout to the problems associated with the testing of large circuit breakers. Finally, a brief reference is made to the part played by field tests and the requirements of a modern testing station.

Make-Break Duties.—In certain circumstances the stresses imposed by a make-break duty can be more severe than either a make or a break taken separately. This applies when the arcing before the contacts touch is appreciable, because the gases so liberated affect the performance on the subsequent break.

B.S. 116, while specifying for test duty (iv) B-3-MB-3-MB, permits this to be split into M-3-M and B-3-B-3-B, if such a procedure is more convenient to the testing station. This concession is invaluable where large circuit breakers are being tested, but it is the authors' opinion that where the make duty is made in this way, a supplementary test duty MB-3-MB should also be performed. Here it should be the aim to make the current comply as closely as possible with the specified values for the making and breaking duties. Where this is not possible, the circuit should be set for the required making current, and if the breaking current is slightly low the test should be acceptable.

Where a make-break duty is made single phase the correct test voltage for the make operation is $V/\sqrt{3}$, but the test voltage for the break operation specified in I.E.C. 56 and B.S. 116 is $1{\cdot}5V/\sqrt{3}$. To comply with the specifications it would be necessary to do the whole make-break duty at the higher voltage. However, if the proposal in section on Single Phase Testing were accepted, i.e. to adopt a factor of 1·0 or 1·2 for single phase tests at 100 per cent duty in e.h.v. circuit breakers, this difficulty would be overcome.

Auto-Reclosing Duties.—Auto-reclosing duties may be high-speed or low-speed or a combination of both. High-speed auto-reclosing is usually associated with large high-voltage circuit breakers. This can be represented by B-*t*-MB where *t* is the dead time of the circuit. In service it must not be less than the time required for the path of the fault arc to be deionised, so that reclosure of the circuit breaker does not cause it to be re-established. Typical minimum values at voltages over 100kV are 10–15 cycles. This test duty can usually be reproduced at testing stations, but the current broken in the second break operation will often be low. Some tolerance here should therefore be accepted.

The more complicated auto-reclosing duties are difficult to reproduce in testing stations. It has, however, been stated that where the dead time is greater than 10 seconds the time interval is not likely to be critical within fairly wide limits in oil and air-blast circuit breakers. This opens up the possibility of simulating the more complicated duties by a succession of B-*t*-MB duties made at intervals of, say, 3 minutes, which is possible at most testing stations.

When a circuit breaker has been proved by full-scale or unit tests for normal break duties it is necessary to check the auto-reclosing performance only at 100 per cent rating and at the current giving the longest arc. Since the B-*t*-MB auto-reclosing duty is more severe than the supplementary make-break duty described in the previous section, the make-break duty can be omitted if the auto-reclosing duty is done.

Single Phase and Two Phase Short-Circuits.—The breaking of single phase and two phase short-circuits introduces other factors which are mainly mechanical ; and where all three poles of a circuit breaker are coupled in such a way that uneven stressing may cause trouble, it is advisable that this point should be checked by test.

Although, in certain system conditions of earthing, the single phase fault current can exceed the balanced three phase fault current, this condition is not common and no special account need normally be taken of this.

Out-of-Synchronism Conditions.[7 10 11] — Large high-voltage circuit breakers are often used for controlling tie-lines between power stations or groups of power stations and may therefore have to open when there is loss of synchronism. Under certain conditions of earthing and simultaneous faults, it would be possible for very high voltages to appear across the poles of a circuit breaker opening a tie-line connecting together power stations which have fallen out of step. For example, the worst possible condition from the point of view of voltage would occur if two systems, each earthed by arc-suppression coils and connected with a single tie, were to fall apart with an earth fault on each. This could produce a recovery voltage of $2V$ (or $3{\cdot}47V/\sqrt{3}$). Similarly, loss of synchronism between one such system faulted, with the other unfaulted, could produce a recovery voltage of $2{\cdot}73V/\sqrt{3}$. Arc-suppression coils are not now normally used at the high voltages at which tie-lines connecting together power stations are energised, and since the fault conditions envisaged are in any case improbable they may reasonably be ignored. A study of power-system conditions over a number of years has convinced the authors that the most severe duty a circuit breaker would be likely to meet under asynchronous conditions on high-voltage systems, where solid earthing is the most common practice, would be to break 25 per cent of the rated short-circuit current at $2V/\sqrt{3}$ (or possibly $2{\cdot}1V/\sqrt{3}$). A test at these values is therefore all that is required. This seems to be in line with the conclusions of most investigators both on the Continent and in the United States, except that in the United States a test voltage of $2{\cdot}5V/\sqrt{3}$ is occasionally mentioned.

Breaking Limited Short-Circuit Currents.—The lowest short-circuit test specified at present is 10 per cent of the rating, except where there is reason to believe that a critical current exists below this value. Circumstances can occur in service, for example, on a remote fault, where it is necessary to break reactive fault currents between the 10 per cent rating and the highest transformer magnetising currents, and a circuit breaker should be able to interrupt such currents. It is therefore often advisable to explore this zone even though there are no special indications of a critical current. An additional test at 5 per cent will usually be adequate.

There is one aspect of tests in this range which is worth considering. In service when a fault current of low magnitude is to be cleared, the bulk of the reactance usually lies between the circuit breaker and the fault. This has an important effect on the distribution of voltage stresses inside the circuit breaker during the arcing period.

While this does not often affect the performance of large circuit breakers, particularly those in which the poles are separated, it can have an effect on the operation of smaller circuit breakers, especially air-break type. With such circuit breakers it is therefore advisable to make some tests in this range with the greater part of the current-limiting reactance, say 80 per cent, connected between the circuit breaker and the fault point. This is sometimes difficult to arrange physically, and as the liability of circuit breakers to fail under this condition is not great, this point should not be overstressed.

Special Tests on Switching Resistors.—Although, in general, the tests required to prove circuit breakers using switching resistors are the same as for those without, it does not necessarily follow that the switching resistors themselves are adequately proved in the process, particularly where unit tests are used.

It is possible in multi-break circuit breakers using switching resistors for an arc to be re-established after current zero in only some of the main breaks, the circuit being completed through the resistors associated with the other breaks. This imposes high stresses both from voltage and thermal effects, and it is necessary to check that the switching resistors are capable of withstanding any such condition which may arise.

Effect of Frequency.—Although strictly speaking, the effect of frequency on short circuit performance is outside the scope of the paper, the results of tests on an oil circuit breaker at 25 c/s may be of interest, since they give an indication of the relative performance at different frequencies.

Tests have indicated that the short circuit breaking duty of an oil circuit breaker may be more severe as the frequency decreases (and vice versa). This is because the longer duration of the current loops may cause an overall lengthening of the arc. If a circuit breaker is to be installed on a system where the frequency differs appreciably from the standard, this must be taken into account.

Normal Service Switching Conditions and Methods of Test

Switching conditions in normal service, as distinct from short-circuits, include the switching of load currents, of transformer magnetising currents and of line-charging currents ; of less importance, because much less frequent, is the switching of shunt reactors and capacitor banks.

With the exception of load switching all these conditions have one feature in common, namely, their liability to produce over-voltages. The maximum permissible over-voltages can be established only in relation to the insulation levels of power systems. This is a subject on its own on which much work has been done, and agreement among the engineers concerned is in sight. The values for the maximum peak voltages to earth which may be permitted are expected to be of the order of five times the normal phase-to-neutral voltage in the 3·3–11kV range, 4·5 times in the 22–100kV range and four times above 100kV.[14]

Load Switching.—The load-switching duty in circuit breakers will nearly always be easier than breaking limited short-circuits and need not normally be considered. Possible exceptions are circuit breakers where the normal load current is high or where the number of operations to be expected in service is abnormally large (e.g. arc-furnace control), although here the main concern will be with the durability of the contacts, and with the degree of oil carbonisation, where oil is present.

The Breaking of Transformer Magnetising Currents.[7 12]—The phenomenon of the breaking of transformer magnetising currents has been very fully dealt with elsewhere, and it is proposed to concentrate here on the practical implication as far as testing is concerned.

The measurement of transformer magnetising currents presents two problems : the first is that the harmonics are often very marked, and the second is that under transient magnetising conditions the current may be almost wholly displaced from the zero line. Reliable measurements can therefore be made only of peak currents ; steady-state peak currents of 50A and transient peak currents of 250A may be taken as being representative of maximum service conditions.

The extent to which over-voltages may be produced depends on a great variety of factors. On the one hand there are the installation factors, such as the size and arrangement of the transformer, the degree of damping provided by the core losses, the presence or otherwise of tap-changing reactors, and the capacitance between the connections and earth. On the other hand are the operation factors such as the magnitude of the current to be broken, whether interruption takes place during the transient or the steady-state and the maximum chopping current of the circuit breaker.

The extent to which testing is possible at testing stations is usually limited by the difficulty in obtaining ordinary power transformers for testing, because the testing-station transformers often have different core-damping characteristics, while if the current is limited by the use of air-

* Abstract of paper "Proving the Performance of Circuit Breakers with Particular Reference to those of Large Breaking Capacity." Institution of Electrical Engineers, London, March 23, 1955.

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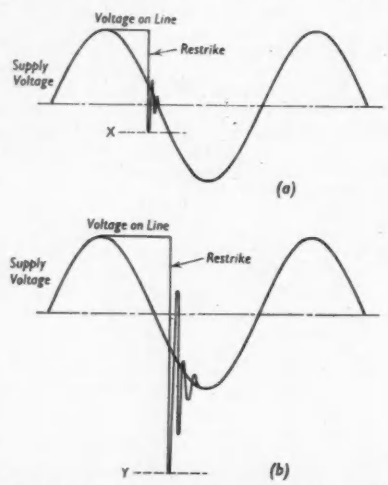
cored reactors, which are usually a part of the testing-station equipment, misleading results can be obtained. Some tests have been made to correlate results obtained on testing-station and ordinary power transformers, and this work is continuing.

Experience indicates that the over-voltages produced in service are moderate ; the highest over-voltages occur where tap-changing reactors are used which, because of their air-gaps, increase the magnetising current taken by the transformer and reduce the damping effects when current chopping takes place. Pending the development of an agreed test circuit in testing stations representative of ordinary power transformers, it is suggested that circuit breakers which are suspected of producing high over-voltages when switching magnetising currents be checked against the known characteristics of a similar circuit breaker which has been tested with an ordinary power transformer.

The Switching of Shunt Reactors.—Although there are certain similarities between the switching of shunt reactors and of transformer magnetising currents, there are two important differences as follows : first, the range of steady-state currents in shunt reactors usually lies between 50A and 250A r.m.s., whereas the steady-state transformer magnetising currents are much smaller. This means that, although the maximum current chopped may be limited with transformer magnetising currents, no such limit exists in the case of shunt reactors. Secondly, the damping in shunt reactors is much less than in power transformers because they are either air-cored or have an air-gap in their magnetic circuit. The effect of both these differences is to produce much higher switching over-voltages. Tests made with air-cored reactors installed at a testing station appear to give fairly representative results.

The Breaking of Line-Charging Currents.[7 11]—The breaking of line-charging currents gives rise to two main problems, namely, the production of over-voltages and the setting up of high shock pressures in arc-control pots of oil circuit breakers. At lower voltages these problems are



(*a*) *X*=Voltage which can be left on line after minor restrike and clearance. (Maximum value is peak supply voltage.)
(*b*) *Y*=Voltage which can be left on line after major restrike and clearance. (Maximum value is 3× peak supply voltage.)

Fig. 9—Comparison between possible over-voltages with minor and major restrikes when breaking charging current

not very noticeable, but they become increasingly important as the system voltage increases, say above 100kV, and occasionally at 66kV when long cables are being switched. The main reason is that the dielectric energy stored in the capacitance of cables or overhead lines increases as the voltage increases.

The mechanism of voltage build-up, when the charging current of lines or banks of capacitors is interrupted, has been described at length in several places, and is well-known. It is an essential part of this process that a succession of restrikes should occur in the circuit breaker prior to the arc being finally extinguished. An important distinction has been drawn between what might be termed minor restrikes, which occur when the arc has been extinguished for less than one-quarter of a cycle, and which cannot leave an enhanced voltage on the line when the arc is extinguished, and major restrikes which occur when the arc has been extinguished for more than one-quarter of a cycle, and which may leave an enhanced voltage on the line in similar circumstances. The difference is illustrated in Figs. 9 (*a*) and 9 (*b*). Unless this enhanced voltage is left on the line it is impossible for the process of voltage build-up (with associated high transient peaks) to begin at all. In judging the performance of a circuit breaker it is useful to take into account the number of major restrikes in addition to the actual over-voltages it produces.

Over-voltages can be produced on both the line side and the supply side of the circuit breaker. These are liable to be greatest when the line-side capacitance is large compared with that on the supply side.

As far as shock pressures are concerned an intermediate value of capacitance on both sides of the circuit breaker (and consequently a ratio approaching unity) is likely to be worst ; this will permit a sudden heavy discharge in an oil-filled arc-control pot. When larger charging currents are being broken the initial arcing (before major restrikes can occur) may be sufficient to create a gas cushion inside the arc-control pot, and this will absorb the shock.

A factor which plays an important part in the production of over-voltages and shock pressures is the inductance of the line. It is doubtful whether the effects of distributed capacitance and inductance can be reproduced, even approximately, by a lumped capacitance only. Other factors which must be taken into account are the method of earthing and whether tests are being done single phase or three phase.

It is beyond the scope of the paper to discuss the breaking of line-charging currents in greater detail. In testing stations equipped with capacitors and reactors to simulate overhead lines and cables, it is possible to make tests which in the magnitude of the over-voltages set up and the severity of the impulse pressures are comparable with those on actual networks. However, the closeness of this relationship is not easy to assess, and it is suggested that proving tests be made on lines similar to those followed for magnetising-current switching ; i.e. circuit breakers for test should be checked against the characteristics of a similar circuit breaker whose performance, when breaking charging currents under representative conditions both on actual networks and in the testing station, is known.

Where large capacitor banks are not available in a testing station a good idea of the number of major restrikes likely to occur can be obtained by switching even small charging currents of a few amperes, and from this the probable over-voltages may be deduced. However, no indication of shock pressures can be found in this way.

The Switching of Capacitors.[12]—The use in service of large banks of compensating capacitors, particularly shunt capacitors, is increasing, and attention must be given to this problem.

Where testing stations are equipped with large banks of capacitors it is possible to make fully representative tests. Two points of particular importance stand out. First, it is necessary to allow for conditions where capacitors connected to the supply side are similar in size to those being switched or even larger. Secondly, it is important so to match the source inductance to the load capacitance that when the latter is connected the steady voltage rise is not excessive, say not more than 20 per cent.

Testing Facilities

Testing Stations.—The range of tests required to prove circuit breakers adequately has been covered, and some indication has been given of the facilities which exist and the limitations which they impose on the proving of large high-voltage circuit breakers. It became apparent to the authors that, although testing-station output could never hope to keep up with system fault capacity, some action was essential to narrow the gap. A study was made of the various possibilities, and the conclusion was reached that satisfactory proving of the breaking and making capacities of large high-voltage circuit breakers could be based on single phase unit tests. On this basis a new testing station was built capable of proving the largest single unit which is likely to be made in the foreseeable future. This station is described in a companion paper.[21]

Field Testing.—In the United States, field tests, i.e. tests on actual power systems, have long played a prominent part in proving large circuit breakers, and more recently, with the opening of the Fontenay Testing Centre,[19] such tests have received added emphasis in France and elsewhere on the Continent. While wishing to acknowledge in every way the value of field tests, it is important to assess them at their true worth and to recognise that they do not provide a complete answer, either in respect of development or proving tests. Here we need deal with the reasons for this only in so far as they apply to proving tests ; first, the limitation imposed by the comparatively inflexible arrangement of a service network will usually prevent the full range of tests from being adequately covered ; and, secondly, there are the limitations imposed by the fact that in most cases the conditions of circuit severity (particularly r.r.r.v.) are only moderate and will often be less severe than those in other locations.

It will be apparent from the foregoing that, as testing-station tests and field tests both have their limitations, which are usually different, the two together can give the complete answer. As testing-station tests are more convenient, they should form the main basis for development and proving. The use of field tests would thus be to check the extrapolation which will always be needed for large high-voltage circuit breakers, from the tests at testing stations, and for correlating actual system conditions with the arrangements at the testing stations.

To obtain the greatest benefit from field tests they should be made not at one centre but at a number of selected points. At such points the provision of firm platforms, where circuit breakers could be erected, and adequate means of access would be a great advantage.

Conclusions

1. The standard proving tests provide a good basis for the test programme, but it is necessary to make a number of additional tests to cater for features not included in standard specifications and to allow for the individual characteristics of the different types of circuit breaker. This applies particularly to large circuit breakers.

2. All aspects of a circuit breaker's performance must be proved and not merely a few specialised aspects (see Section 1).

3. Service conditions provide the only proper basis for testing (see Section 3).

4. The proving of circuit breakers could be improved by changes in, and additions to, existing standard tests, for example :—

(*a*) More precise definition of the asymmetrical test.

(*b*) Increase in the minimum recovery voltage permissible for large circuit breakers.

(*c*) Specification of standard values of the r.r.r.v.

(*d*) Revision of test voltages for single phase tests on large high-voltage circuit breakers.

(*e*) Larger tolerances in the currents when testing large circuit breakers.

(*f*) Inclusion of at least one make-break test.

(*g*) Inclusion of single phase and/or phase-to-phase tests.

(*h*) Testing large high-voltage circuit breakers under out-of-synchronism conditions.

(*j*) Inclusion of a 5 per cent test duty.

5. The most acceptable solution of the problem of testing large circuit breakers whose short-circuit rating is larger than the testing plant available is likely to be found in single phase unit tests. Synthetic tests have a limited application for making-capacity tests, but their validity for proving purposes is doubtful.

6. Consideration should be given to the standardisation of tests (correlated with system conditions) required to prove normal switching duties, such as load switching, transformer magnetising-current switching, and live-line switching ; these are at present not covered by any standard test rules.

7. Tests at testing stations and in the field are complementary rather than alternative, and extensive use should be made of both for complete proving.

8. Examples of typical test schedules for two widely dissimilar circuit breakers are given in an appendix to the paper.

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Technical Report

Testing Concrete by an Ultrasonic Pulse Technique. Road Research Technical Paper No. 34. H.M. Stationery Office. Price 2s. 6d.—Until recent years the only way in which the physical characteristics of concrete and the changes brought about by ageing and other causes could be determined was by tests to destruction carried out on specially prepared specimens. These tests were useful, but not entirely satisfactory because of variations in compacting conditions in specimens and structure. The need of the engineer for a non-destructive technique for concrete testing was met by the development, at the Road Research Laboratory, of the ultrasonic pulse method, equipment for which is now manufactured in this country.

The scope of the method is outlined in this report. It describes the ultrasonic equipment, which uses two transducers placed on opposite faces of the concrete being tested. Pulses are timed electrically as they pass from one transducer to the other through the concrete and the time of transmission indicates the characteristics of the concrete and the presence of internal cracks. A study has been made of the various factors, such as age, nature and proportions of the mix, moisture content, the presence of mild steel reinforcing bars and so on, on the transit time of the pulses between the transducers. The effect of these factors on the ultrasonic testing technique is discussed.

One of the advantages of this method of testing is that it can be applied to concrete *in situ* and it can detect any deterioration due to weakness or poor compaction. Examples are given of the practical applications of the method. The use of the ultrasonic technique for testing road surfaces is also dealt with. This involves the use of reflection, the sound pulses being thrown back by the lower boundary of the slab. The method can only be used satisfactorily when the underside of the slab is relatively smooth. The paper also refers briefly to the application of the technique to materials such as soil cement, rocks, ceramics and wood.

Valve Voltmeters

THREE valve voltmeters have recently been introduced by Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. Two of these voltmeters (E7555/2 and E7555/3) are general-purpose laboratory instruments, capable of measuring both direct and alternating voltages. The third instrument (E7556) measures only alternating voltages, and it incorporates a wide-

Fig. 1—Valve voltmeter E7555/2, for general laboratory use, with ranges for alternating or direct voltages up to 15kV

band amplifier to give increased sensitivity. All three instruments are mains operated.

The universal instruments (E7555/2 and E7555/3) differ only in the range of voltages for which they are designed. The second instrument covers the range 100mV to 500V d.c. or peak a.c., while the first-named instrument (illustrated in Fig. 1) has additional ranges up to 15,000V. The only difference in the appearance of these two instruments is that there are no high-voltage terminals on the E7555/2 voltmeter.

An input of 0·5V peak a.c. and d.c. gives full-scale deflection on the most sensitive range, and stabilities of zero setting and calibration are exceptionally good. Both positive and negative direct voltages can be measured with respect to earth or other reference potentials, up to a maximum of 500V. For a.c. measurements, a probe is provided which incorporates a double diode valve. One diode is used as a peak rectifier, while the other balances out the effects of contact potential and residual diode current. The frequency response is stated to be level between 30 c/s and 100 Mc/s. The probe input resistance (a.c.) is given as 3·5 megohms at frequencies up to 50 kc/s, falling to 8·5 kilohms at 45 Mc/s; the capacitance is constant at 9 pF.

The d.c. circuit of the voltmeters takes the form of a balanced four-valve amplifier. Two "EF86" pentodes connected as a "long-tailed pair" are directly coupled to balanced

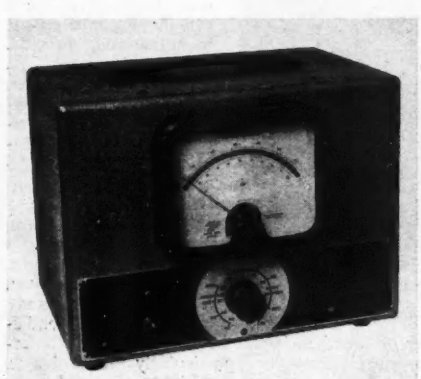


Fig. 2—High-sensitivity valve voltmeter E7556. It is suitable for alternating voltages between 0·5mV and 300V at frequencies from 20 c/s to 1 Mc/s

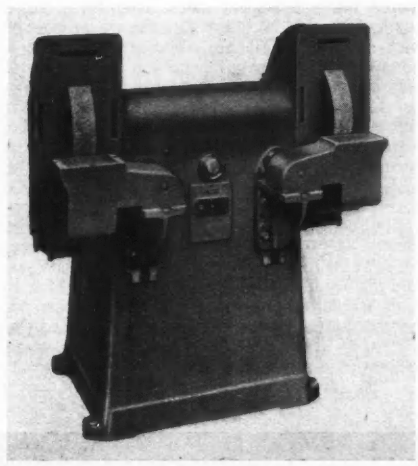
cathode followers. The output of the cathode followers is connected back to the grids of the long-tailed pair, providing virtually 100 per cent negative feedback. This arrangement results in a high input impedance (10 megohms on the 0·5V d.c. range) and exceptional stability. Variations of mains voltage and ageing of valves have very little effect on accuracy.

The meter measuring element, which has a 5in mirror scale, is connected between the cathodes of the cathode followers.

The high-sensitivity voltmeter E7556 (Fig. 2) is designed to measure alternating voltages between 0·5 millivolt and 300V in the frequency range 20 c/s to 1 Mc/s with a total error of less than 4 per cent. Its circuit consists of an input cathode follower feeding into a three-stage, wide-band amplifier with negative feedback. The amplifier output is rectified by a diode and displayed on a 5in mirror scale meter. The frequency response is flat within 2 per cent over the range 20 c/s to 1 Mc/s. On the lowest range (10mV f.s.d.) the input resistance is 1·5 megohms at 20 kc/s and 0·7 megohms at 1 Mc/s, the input capacitance being 15 pF. On ranges of 3V f.s.d. and over, the corresponding values are 1·9 megohms, 0·7 megohm and 6 pF. A lamp bridge circuit provides an accurate calibrating voltage of 10mV at mains frequency.

Dry Grinding Machine

THE double-ended, dry grinding machine illustrated below is now being made by Beacon Machine Tools, Ltd., Hurst Lane, Tipton, Staffs, and incorporates the dust-suppression technique known as "external dust control" developed by the British Cast Iron Research Association. In this design an extractor cowling arranged round the grinding wheel leaves only a small section of the wheel exposed through a closely fitting front hood plate. This plate has formed in it a vertical slot on each side and a horizontal slot above the wheel. When the machine is in use a



16in high-speed double-ended dry grinder with external dust control

continuous stream of air, drawn into the extractor cowling through these slots and a perforated work rest, removes dust generated in grinding.

The machine has a heavy cast iron cabinet body in which the wheel spindle is supported at each end on two ball bearings. The spindle takes 16in diameter by 3in wide bonded wheels and is driven through vee belts by a 5 h.p. motor in the base of the machine. Two spindle speeds of 2180 r.p.m. and 2450 r.p.m. are available, and the hinge-mounted motor can be raised by a quick-action toggle for speed-changing.

The dust extractor cowling on each wheel has two connections, one at the bottom for drawing dust-laden air through the work rest, and one at the top drawing the air through the hood plate slots. These connections are designed for easy coupling to a main extractor system. The work rests are fitted with renewable "Meehanite" perforated pads. Extractor ducts formed integrally with the rests are a sliding fit in the wheel cowlings.

Sandwich Structures for High-Temperature Service

BY OUR AMERICAN EDITOR

As the speed and payload requirements of aircraft have increased in recent years, there has been a continuous search for materials of higher strength-to-weight ratios. The advent of jet propulsion has caused temperature to be introduced as an additional factor in materials selection. In the United States honeycomb structures of all-metal construction are believed to constitute the best available solution to many structural aircraft problems, and this article reviews a number of representative applications in this field.

AT present, temperatures are on the increase both inside and outside of aircraft, rockets and guided missiles. Larger engines are required to achieve the higher speeds demanded, and jet engines, afterburners, ram jets, and rockets are large heat sources which must be made of and contained within temperature-resistant materials. On the outside of aircraft, to-day's high speeds are raising the skin temperatures due to air friction and compression. Unfortunately, the strength properties of light metals fall off sharply at elevated temperatures and consequently other materials have had to be used where sustained elevated temperatures are being encountered. While titanium and its alloys show promise for applications involving temperatures up to 900 deg. Fah., much development and testing remains to be done in this rather new field. Stainless steels and other high alloy steels show the most promise for high temperature applications because of their strength and oxidation resistance. However, their high specific gravities have constituted a problem, which is now being circumvented by employing the concept of honeycomb structures.

A honeycomb structure, such as the one illustrated in Fig. 1, may be considered as an anisotropic, integrated sheet metal assembly. More particularly, in the latest American examples of such structures, foil-thin ribbons arranged in a honeycomb pattern comprise the core which is securely sandwiched between the metal facings or skins. These facings are the prime load-bearing members, and by proper design, complete surface stabilisation has been found to permit ultimate compression strengths to be realised, even in the thinnest gauge faces. The core performs the important function of providing essentially continuous support to the facings to prevent buckling under compression, while at the same time transmitting shear stresses, and the resulting structure permits extraordinarily high strength-to-weight ratios to be achieved. Furthermore, excellent stiffness, vibration damping and thermal and acoustical insulation properties are being obtained. Since all-metal honeycomb sandwich construction offers a practical solution for applications at elevated temperatures up to at least 1500 deg. Fah., the Solar Aircraft Company, of San Diego, California, is conducting a development programme to produce these structures by means of high temperature metallurgical joining techniques. The current programme includes considerations of basic design, methods of core manufacture and contouring, brazing materials, production brazing techniques, physical testing and service evaluation.

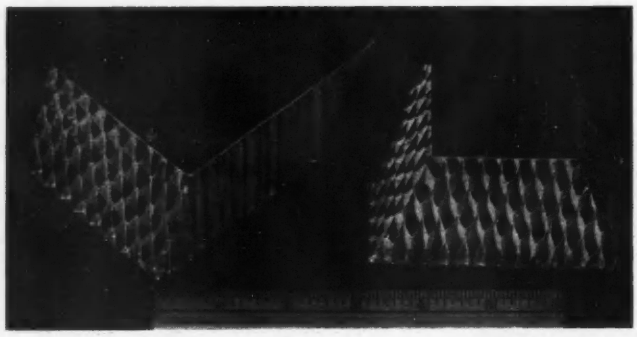


Fig. 1—Brazed honeycomb structure of all-metal construction

Core Materials and Design

The material specification for the company's honeycomb structures are based on expected service conditions and environment. The facings or skins for the structural sandwich usually lie within the range of 0·010in to 0·030in in thickness, while the core stock runs from 0·001in to 0·010in in thickness. The high-temperature, corrosion-resistant metals which have been used by the company include A.I.S.I. type 321 titanium-stabilised 18–8 stainless steel, Armco "17–7 PH" precipitation-hardenable 17–7 stainless steel, Inconel-X, and the "Multimet" and No. 25 "L-605" alloys of the Haynes Stellite Division, Union Carbide and Carbon Corporation. Fig. 2 presents comparative curves for a number of these alloys, showing yield strength per unit weight versus temperature. Below about 900 deg. Fah., the superiority of the 17-7 precipitation hardenable stainless steel is evident, while higher temperatures indicate the desirability of using Inconel-X. Only extreme temperatures require the use of the "L-605" alloy.

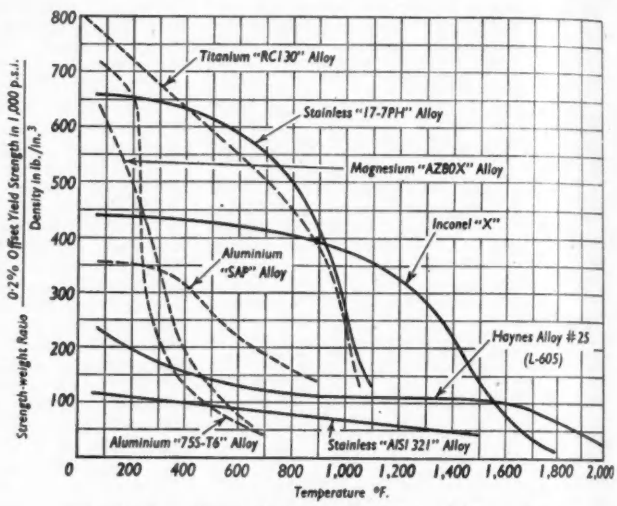


Fig. 2—Comparison of strength-to-weight ratio/temperature curves for various alloys

American steel sandwich core is now usually manufactured in the form of square or hexagonal honeycomb or in wave form cells, although numerous other special core designs have been experimentally produced. Fig. 5 shows the popular "Squarecell" core of the Solar Aircraft Company. While this honeycomb core is manufactured in the fully open condition, it may be collapsed if grinding or machining operations are required. Such straight-cell cores are anticlastic, which means that when the core is bent in simple curvature it reacts by assuming a "saddle" condition, and the expected convex face becomes concave in a direction perpendicular to the bend line. Another interesting core, which is particularly useful due to its optimum strength-to-weight ratio, is known as the "egg-crate." In this core the longitudinal and transverse ribbons are each slotted half-way and then simply assembled slot to slot. This simple egg-crate core resists bending completely along the longitudinal and transverse axes, while intermediate bending between these directions is acutely anticlastic.

The above core designs generally are not suited for sandwich parts having severe two or three-dimensional curvature. Square-cell cores, having narrow node bonds compared to the node width, as shown in Fig. 5, can accommodate slight bending providing the radius is ample or the core height relatively shallow. Straight-cell cores, on the other hand, may be damaged if bending is attempted in other than the normal node.

Recently, a number of interesting honeycomb cores have been developed primarily to accommodate curved sandwich applications. An example of such designs is the "Sinecell" core of the company, which is shown diagrammatically in Fig. 5. As illustrated in Fig. 3, this particular sandwich construction permits two and three-dimensional curvatures of a small degree. While adhesive bonding and resistance welding are at present the two chief methods of assembling ribbons into core, other techniques employed in the United States include wire stitching, eyeletting and slotting. A process not employing ribbons but rather starting from a single sheet makes core in a manner similiar to the manufacture of "expanded metal."

Contouring and Bonding

The machining or grinding of flat honeycomb core is not a serious problem if the core can be collapsed for the operation. However, if the core cannot be collapsed or the surface is to be contoured, a real problem presents itself, since the tolerances required for brazing must be within ±0·002in. Among the solutions which have been found is a method of freezing the expanded core in ice and performing the necessary milling operations at freezing temperatures. Another method employs a plaster of Paris composition to hold the core for contouring purposes. Electrical disintegration by means of "spark machining" is another technique for core contouring which may prove practicable in production.

The bond between the face skins and the honeycomb core can be of exceptional strength in an all-metal sandwich, as has been found by both physical testing and metallurgical studies. In the course of this work, two principal approaches were investigated, namely, welding and brazing. Attempts at solid-phase welding proved unsuccessful, due to a combination of low diffusion rates, an inadequate core strength and only point-to-point contact. Extensive efforts have been directed towards electrical resistance methods of welding core to skin, and it is believed that this method has definite possibilities. As an example, the company produced a curved sandwich section from 0·002in thick "Squarecell" stainless steel core and faces employing a modified 100kVA seam welder equipped with roller electrodes. Under the best conditions obtainable, however, only about 25 per cent of the core-end area could be considered as satisfactorily welded to the faces. Severe problems were encountered in producing consistent high

quality welds in reasonable continuity. Furthermore, difficulties were found to be associated with the non-destructive inspection of such welded panels.

From the beginning of this work, metallurgical brazing studies showed considerable promise. It was found that if braze metal flow occurs at all, the wetted areas are prepared for brazing which, if properly controlled, ensures the establishment of high bond strengths. The company has developed the so-called "Solabraze" range of high-temperature materials for the brazing of honeycomb structures, and this material has met the structural requirements completely. It is now felt that only brazing ensures a continuous, sound metallurgical joining of the structural components. Due to the formation of fillets between mating surfaces, greater bond area results with an attendant uniform stress distribution. Also, the skins spanning each cell are further stiffened or stabilised, which is a significant advantage when relatively thin faces are employed. Furthermore, the brazing alloy infiltrates the node laps, resulting in an improvement in their column strength and shear properties. With the use of excess braze material, the sandwich strengths increase further, but the weight increases at an alarming rate.

Fabrication by Brazing

In assembling the flat or contoured honeycomb core with the faces to form a useful structure, only clean, degreased, and occasionally pickled metal surfaces are employed. Brazing alloy is applied as a granular powder in measured quantity directly to the core nodes and is held in place by a volatile, plastic solution. Small amounts of special fluxes may be applied during this operation. Preliminary experiments have been made recently which showed the feasibility of applying the braze-flux mixture in a plastic film or tape. This film is simply placed between the core and the face sheet and, because of the remarkably free flow of the alloy during brazing, only one sheet is required to braze both faces.

The actual sandwich fabrication involves a number of considerations, of which the more important ones are as follows: (1) Proper prepositioning of brazing alloy and flux. (2) Correct positioning of structural components and fixtures. (3) Accurate maintenance of the assembly during the brazing-joining operation, with metal-to-metal contact between faces and core. (4) Control of heating and cooling rate to prevent warpage and stressing of the part. (5) Maintenance of adequate atmospheric protection to ensure a clean, non-oxidised assembly and brazed joints of high quality. (6) Controlled post-heat treatment operations to develop desired metallurgical conditions within the sandwich materials. (7) Sizing, coining, or other plastic deformation of the brazed panel to develop a precise part and to effect strengthening by cold work. The importance of these considerations should not be minimised, especially since even minor repairs to a brazed panel are frequently prohibitive.

Fig. 4 shows a perfect metal-to-metal "Tee" butt-joint found in a high-quality sandwich. Such a sandwich has continuous fillets and

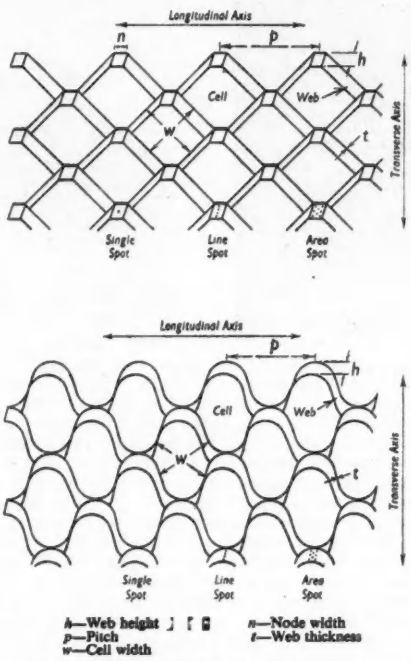


Fig. 5—Configuration of solar "Squarecell" (above) and "Sinecell" (below) honeycomb cores

exhibits optimum strength with excellent weight economy. Since high-temperature structural sandwich applications are based on the ability to develop very high strengths, a 99·44 per cent braze integrity is believed to be mandatory. The most significant single factor in ensuring this high standard is the maintenance of intimate contact of components throughout the brazing operation. This must be done at brazing temperatures in the neighbourhood of 1900 deg. Fah. concurrently with achieving the desired structural form which may specify aerodynamic smoothness on both surfaces. While non-destructive testing standards have not been established for all-metal honeycomb structures, there is good reason to believe that practical solutions to this vital problem are possible. Since the mere existence of braze fillets in the structure is sufficient evidence that wetting, capillary flow, and resulting metallurgical bonding has taken place, both X-ray and sonic methods hold promise for determining fillet existence in inspecting these all-metal honeycomb structures.

Physical Properties

It is felt that by means of high temperature brazing, the strength of all-metal honeycomb sandwich structures can be maintained at elevated temperatures. The compressive strength of the sandwich is, of course, dependent upon cell design, and, through proper choice of cell configuration and material, values as high as 4000 lb per square inch have been realised in cores comprising 0·002in thick by ¼in cell width honeycomb. It has been established that the creep properties of high-temperature brazed construction is superior to adhesive-bonded sandwich at all temperatures. Tests extending up to 1650 deg. Fah. have shown "Solabraze" brazing materials to have excellent creep resistance. A favourable impact strength of all-metal sandwich structures has been indicated by battle damage experiments. When honeycomb panels were subjected to the impact of a 20mm projectile, it was noted that the extent of damage is localised and skin peeling is halted at the cell wall joint. Advantage may be taken of this inherent battle damage resistance by employing all-metal sandwich as integral fuel tanks in such structures as missile wings.

While few physical property data exist relating to metallic honeycomb structures, active investigations are now being sponsored by the Wright Air Development Centre at such institutions as the Forest Products Laboratory of the U.S. Department of Agriculture. Strength values are in every case dependent upon a given sandwich design. As a specific example a heat-treated panel ¼in thick, constructed of "Armco 17-7PH" stainless steel with 0·002in by ¼in "Squarecell" core and 0·015in thick faces, yielded the following representative values :——

	Temperature		
	75 deg. Fah. Per square inch	800 deg. Fah. Per square inch	1,000 deg. Fah. Per square inch
Tensile strength (face after brazing)	175,000 lb	115,000 lb	60,000 lb
Edge compression ...	180,000 lb	130,000 lb	60,000 lb
Flat compression ...	4,000 lb	2,600 lb	1,300 lb
Maximum core shear	500 lb	400 lb	350 lb

Applications of Structures

All-metal sandwich structures are so new that no known applications have reached the production stage. There are, however, a number of items in various phases of development, and they are discussed below.

An interesting application for brazed, high-temperature honeycomb sandwich was developed by the company in close co-operation with a leading American aircraft manufacturer. It

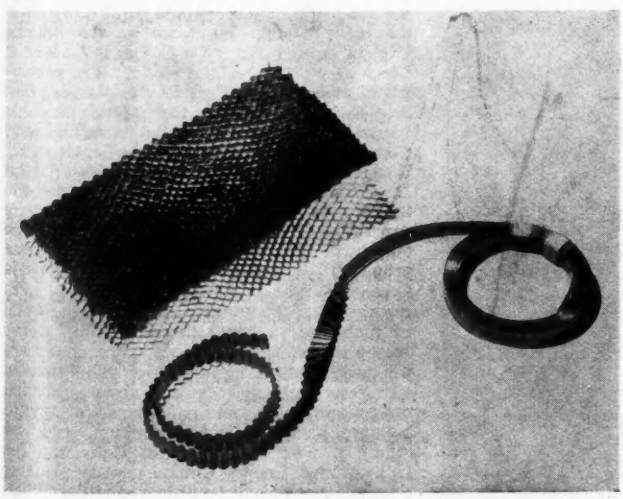


Fig. 3—Construction of "Sinecell" honeycomb core from stainless steel ribbon

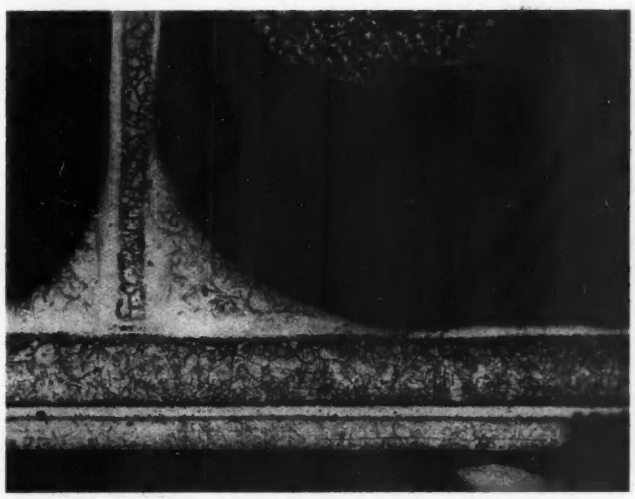


Fig. 4—Perfect example of brazed butt joint in an all-metal sandwich structure

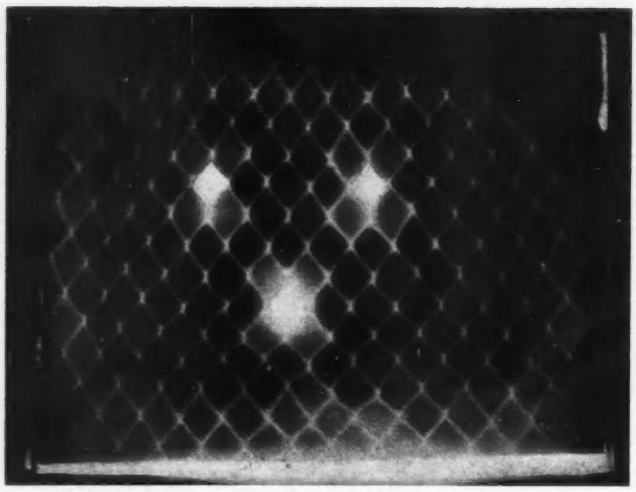


Fig. 6—Honeycomb structure used as the door of an electric furnace operating at 1750 deg. Fah.

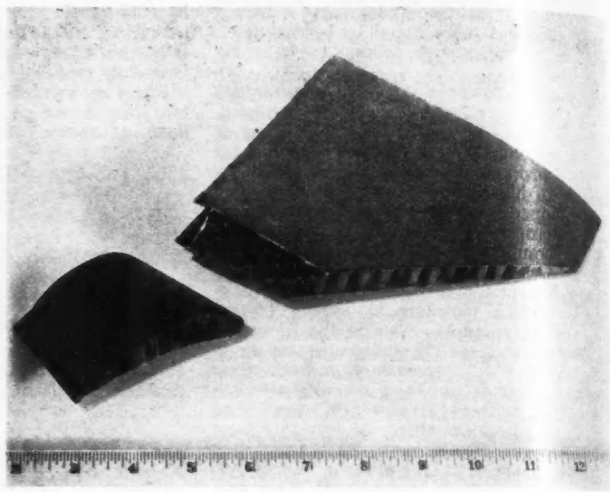


Fig. 7—Two examples of shaped components fabricated from all-metal honeycomb sandwich

involved the design and fabrication of a stand-off, self-supporting after-burner shroud around a tailpipe operating above 2000 deg. Fah. Both insulation and reflective heat barrier properties were desired in a strong, light-weight, fatigue-resistant structure. From experience with solid sheet metal shrouds, the actual sandwich service temperatures were predicted to range from 750 deg. to 900 deg. Fah. The completed unit is shown in Fig. 8 and represents what is claimed to be the largest commercial all-metal honeycomb sandwich structure in the United States to-day. It has proved successful in flight tests under severe conditions. In making this unit eight curved panels were assembled by edge fastenings to form split halves of a tube 5ft long by 2ft in diameter. It is of interest to note that the thin-skinned honeycomb sandwich accounted for only one-half of the 28 lb total weight of the shroud. Some 14 lb of sheet metal were required for edge strips, channels, pads, rivets and attachment flanges. While the design specified the use of 0·002in A.I.S.I. type 321 stainless steel face and core material, such foil in a 24in width was only obtainable in 0·0026in gauge. Thus, weight economy suffered to the extent of 1½ lb because of this seemingly minor detail. However, lighter-gauge stainless steel foil in such considerable widths is likely to become available in the near future as wider Sendzimir cluster rolling mills are built with work rolls of sufficiently small diameter.

To determine the heat-insulating value of this honeycomb structure, a section was used as the door of an electric furnace operating at 1750 deg. Fah. The photograph reproduced in Fig. 6 was taken of the cold side and portrays the insulation value of such an all-metal sandwich. The two upper diamond spots expose the inner skin as the outer cell skin has been removed. An optical temperature of 1550 deg. Fah. was recorded under black body conditions. The lower, brilliant area permits a direct view of the furnace at 1750 deg. Fah. as both sandwich skins are absent. The cold skin temperature was approximately 1300 deg. Fah. It was noted that the core cell pattern, being roughly 50 deg. hotter than the cell face, stood out in contrast, thus giving proof of the relatively high insulating value of each air cell.

Evacuated shroud panels using non-permeated core have been made successfully and an additional thermal drop amounting to about 60 deg. Fah. has been noted. This honeycomb core was of ⅛in cell width "Squarecell" with faces of 0·002in Inconel. Further work along these lines is indicated and metal gauges greater than 0·002in will be used to ensure vacuum tightness.

Refined fabricating techniques have made it practical to produce high strength sandwich having one or both faces of a perforated or permeable metal. Such constructions are designed for applications requiring fluid flow through a skin for either cooling or heating purposes. The familiar term "sweat-cooled material" has increased significance when one considers the possibilities of such an integrated structure. It has the strength/weight advantage of all-metal sandwich in addition to serving as a fluid manifold. Moreover, as the honeycomb core is a particularly good stabiliser, very thin skins become feasible, thus reducing the pressure drop and the panel weight.

The aircraft industry has already made considerable use of corrugated sandwich core for heat exchangers in such applications as anti-icing leading edges, air-cooled turbine blades and heated inlet guide vanes. It is now believed that honeycomb structures offer the distinct advantage of substantially greater outer surface support or skin stabilisation, while accommodating the necessary fluid flow. The company is exploring the possibility of using all-metal honeycomb construction as rotary pressure seals. Tests will determine the effectiveness of this proposal, particularly in the high temperatures encountered in jet engines.

Fig. 8—After-burner shroud for jet engine made from all-metal honeycomb sandwich structures

The extensive applications requiring contoured cores cannot be put into practice until satisfactory core machining methods and sandwich assembly techniques have been obtained. Fig. 7 represents two experimental shaped parts which have been successfully fabricated by high-temperature brazing. These cores for the turning vane and the missile fin section were mechanically machined using the plaster support method. The fixtures used in the fabrication of these components were very critical because an intimate core-to-skin contact had to be maintained during the brazing cycle. It is expected that such contoured sandwich structures will find application in aircraft leading edges, fins, control surfaces and slats.

Because of the exceptional metallurgical bond strengths which characterise high-temperature brazed parts, it has been found feasible to stretch-form brazed sandwich members. Several stretch-wrapped panels and stretcher-levelled panels were produced by the company recently. Flat sandwich specimens ¼in thick with 0·010in thick A.I.S.I. type 321 stainless steel skins were bent to radii of 5in to 7in. The maximum permanent set for these particular sandwiches was approximately 10 per cent. Precise stretcher levelling was performed with elongations of 1 per cent or more, and a significant improvement in stiffness accompanied the plastic deformation.

Geneva Conference on Atomic Energy

PRELIMINARY plans have now been announced for the participation by the United States in the International Conference on the Peaceful Uses of Atomic Energy, which is to be held at Geneva from August 8th to 20th. The primary responsibility for the technical planning and preparation of the American participation has been assigned to the U.S. Atomic Energy Commission, which has appointed Dr. George L. Weil, a former assistant director of its Reactor Development Division and now a consultant to the Commission, as technical director for American participation. The conference is an outgrowth of the so-called atoms-for-peace proposals laid before the United Nations in December, 1953, by President Eisenhower, when he urged that the atomic resources of the world be mobilised to apply the benefits of atomic energy to the cause of peace. The conference will be devoted to the presentation of information on reactor technology, atomic power, radiation protection, applications of atomic energy to biology, medicine, and agriculture, and the industrial uses of radioactive isotopes. The U.S. Atomic Energy Commission is planning a technical exhibit to be displayed at the conference site. More than sixty institutions and firms already have signified interest in participating in this U.S. Government exhibit.

Industrial and Labour Notes

Economic Survey, 1955

The *Economic Survey*, 1955, was published by H.M. Stationery Office on Tuesday afternoon. It presents, like its predecessors, a fairly comprehensive review of economic affairs in 1954, and then sets out some observations on this country's present economic outlook and immediate and long-term prospects.

In this section of the *Survey* it is stated that no offset to additional import expenditure can be expected in the near future from higher invisible earnings. In these circumstances, a continued rise in demand for imports cannot be reconciled with the need for a surplus on the balance of payments unless there is a considerable increase in export earnings. It is urged, therefore, that industry should seize every opportunity of developing sales abroad and securing as large a share as it can of what are now expanding markets.

As to the immediate industrial prospects in the United Kingdom, the *Survey* says that fixed investment is likely to be substantially higher this year than last. In the basic industries, the upward trend continues, and further increases are expected this year in coal mining, electricity, gas, rail and air transport, and Post Office services. These increases are estimated at about £75,000,000, and are predominantly in plant, machinery and vehicles rather than in building. The *Survey* goes on to refer to recent encouraging signs that investment in some branches of manufacturing industry is rising, though, it says, the pattern is not uniform. In certain industries, such as oil refining, large programmes of expansion are now nearing completion and investment is falling off. Government-financed expenditure on equipping factories for defence production is declining from the peak reached in 1953. Reductions in these sectors, it is added, have to be set against the increases expected elsewhere—for instance, in iron and steel, motor manufacture, chemicals and synthetic fibres.

The *Survey* says that two particular sectors of industry which are likely to be fairly fully extended in 1955 are building and engineering. The engineering industries are no longer being called upon to meet additional defence claims, but, the *Survey* states, there is strong demand at home and abroad for most kinds of capital goods, motor-cars and metal consumer goods. In addition, it is noted, there is no sign of trade in chemicals slackening here or overseas. Then, the *Survey* comments, from the point of view of the balance of payments, developments in coal and steel and agriculture are of particular importance. There is a reference to the "disappointing" coal production last year. The increase in colliery output in 1954, the *Survey* notes, was less than 1 per cent above the preceding year, and output in recent months has been lower than in the corresponding months of 1954.

National Coal Board's Organisation

In these notes in our issue of February 25th, we recorded the reconstitution of the National Coal Board following the recommendation of an advisory committee on organisation. This committee was set up, under the chairmanship of Dr. A. Fleck, at the end of December, 1953, and after a detailed investigation of the Board's organisation and activities presented a report early in February.

The reconstituted National Coal Board has now taken various decisions about its organisation and about the way in which it should be made to work. There is to be no change in the main structure of organisation. The collieries will continue to be administered in areas and the areas will continue to be responsible to the eight main divisional boards. There will continue to be a divisional board for Kent. This decision accords with the advice of the Fleck committee that the main structure of the organisation contains "no big defect which is hampering the industry in solving its problems." Nevertheless, the Coal Board's departmental organisation is to be changed and strengthened, and three new departments—staff, industrial relations, and purchasing—are to be set up. The successful implementation of these decisions, the Board says, depends upon appointing to the new posts people with the right qualities. The Board is determined to do this, although it may mean some delay. The Board says, also, that it will proceed on the lines recommended by the Fleck Committee for the improvement of management at all levels. It intends to take all the necessary steps to make the policy of decentralisation work properly and effectively. To this end the Board proposes to see that management in the coalfields is at all times of the right calibre and that it enjoys properly defined powers.

Development of the Coal Industry

In the course of a speech which he made at Birmingham last Friday, the Minister of Fuel and Power, Mr. Geoffrey Lloyd, said that the British coal industry had made a fresh start. The reconstituted National Coal Board had announced its first steps in a new drive to improve the management of the industry at all levels—at the pit, at the level of the fifty area general managers, and that of the nine divisional boards. The Minister went on to say that he particularly welcomed the Board's decision to establish a new staff department concerned with the management side of the industry and with recruiting and training the men on whom the leadership of the whole industry depended, and who must measure up to the highest standards of modern industrial management.

The Minister added that one condition of the industry's success in meeting the nation's mounting need for coal was the physical and technical reconstruction of the pits. The Coal Board, he said, was taking various steps to accelerate this matter. There was, however, a complementary condition of success, and that was the progressive improvement of human relations throughout the industry. Such improvement, of course, depended on the miners as well as on the management. But, the Minister emphasised, the Board's responsibility was management, and that was why the new decisions to inaugurate a managerial renaissance in the industry were particularly significant.

Pressure on Manpower

Some observations on the main changes in employment in Great Britain and about manpower prospects are made in the latest issue of *Bulletin for Industry*, which is a review of the economic situation prepared by the information division of the Treasury. The *Bulletin* points out that last year civil employment rose by 350,000 or 1·5 per cent, which was a bigger increase than in any year since 1947. The greatest change was in manufacturing industry, which took on another 258,000 workers, of whom 177,000 went to the metals, engineering and vehicles groups. There were smaller gains in some other manufacturing industry groups, and in textiles and clothing there were small decreases. Outside the manufacturing industries, the biggest changes in manpower were an increase of 77,000 in the distributing industries and a decrease of about 20,000 each in transport and agriculture.

The *Bulletin* goes on to say that the evidence of a considerable growth in the demand for labour is supported by the statistics of hours worked, of unemployment and of vacancies unfilled. Short time in the manufacturing industries last year was negligible and affected only one operative in 200, but overtime continued to increase, especially in the metals, engineering and vehicles group. In the last week in November, 28·5 per cent of the operatives in manufacturing industry were working overtime. Unemployment last year reached a very low point, the lowest in peacetime apart from 1951. On February 14th this year, unemployment, at 282,000, was 1·3 per cent of employees and compared with 1·8 per cent in February, 1954. Unemployment in February this year was low in all regions of Great Britain, though there was a considerable range from 0·5 per cent in the Midlands to 3 per cent in Scotland. The number of vacancies unfilled at employment exchanges, the *Bulletin* adds, has also been rising, and in February this year it was 36 per cent higher than a year earlier. Vacancies last year were in excess of unemployment in most regions, the main exceptions being Scotland, Wales and the Northern Region. In the metal-using industries, vacancies on February 9, 1955, totalled 69,000, or over one-third more than a year earlier. Vacancies for skilled engineering workers increased slightly less last year. Some of the sharpest increases were in metal goods manufacture, transport and distribution.

About manpower prospects, the *Bulletin* says that some further increase in the working population is likely this year, although industry cannot count on as much as last year. Nor is any noticeable increase in working hours likely. In the manufacturing industries in October last, working hours were provisionally estimated at 46·3 a week compared with 45·9 a year earlier. Further increases in production, the *Bulletin* comments, must come largely from higher output per man-hour. This, of course, underlines the importance of reorganisation schemes, work study, mechanisation, joint consultation and the like, which raise efficiency and output without increased demands on scarce labour supplies. The labour shortage also emphasises the importance of locating new projects with big manpower needs in regions where the pressure on labour supplies is least.

T.U.C. and Financial Information

The British Institute of Management has set up a committee to study "the disclosure of financial information to employees," and the Trades Union Congress has submitted a memorandum to the committee setting out its considered views on the subject. In this memorandum, the T.U.C. suggests that the directors of many companies put a cloak of secrecy around the financial affairs of their businesses, and often make it quite impossible for most of their employees to find out just what a firm is earning.

The T.U.C. thinks that all companies, whether public or private, should readily discuss their financial affairs with their workers and give them detailed information to make such talks effective. If the companies did so, the T.U.C. submits, they would secure the real advantages that come from better industrial relations. The memorandum goes on to say that, basically, trade unions are as interested in industrial progress as management, "for the maintenance and development of their pay packets and standards of working and living depend on it." The trade unions, it is stated, are spending considerable sums of money in technical training devoted to improving negotiating and consultative skills. The T.U.C. thinks, however, that "many difficulties exist which must be removed, an important one being the impression of secrecy and restriction created by non-disclosure or reluctant disclosure of basic information on which good relations depend."

What often happens now, the T.U.C. claims, is that unions go into negotiations with only scant knowledge of how employers' products are selling and of employers' "ability to pay." In such conditions, it is argued, it is impossible to create mutual confidence. An assessment of what is reasonable, the memorandum urges, should be based on detailed information. The assessment of reasonable wage rates, the T.U.C. says, has been prejudiced because of inadequate availability of financial information and the development of an atmosphere of secrecy. The memorandum adds that "employers do themselves no good, and industrial relations much harm if wittingly or unwittingly they generate an atmosphere of suspicion through secrecy."

Personal and Business

Appointments

LORD KERSHAW has been appointed chairman of High-Pressure Components, Ltd., and Sun Engineering (Richmond), Ltd.

MR. W. V. BINSTEAD has joined the development engineering department of the British Welding Research Association.

THE GLANMOR FOUNDRY COMPANY, Ltd., Llanelly, states that Mr. D. J. Auld, chief metallurgist, has been appointed a director.

LAURENCE, SCOTT AND ELECTROMOTORS, Ltd., announces the appointment of Mr. E. Yeeles, M.I.Mech.E., as works director at Norwich.

MR. S. B. HARTSHORNE, A.M.I.Mech.E., has been appointed chief development engineer of Henry Meadows, Ltd., Fallings Park, Wolverhampton.

THE BRITISH TRANSPORT COMMISSION states that Mr. K. Brinsmead has been appointed assistant civil engineer (permanent way), British Railways' central staff.

MR. G. W. PARKIN, A.M.I.E.E., has been appointed electrical assistant to the chief mechanical and electrical engineer, British Railways (London Midland Region), Derby.

THE BRITISH ELECTRICITY AUTHORITY states that Mr. R. J. B. Tiernay has been appointed accountant of the Midlands division, in succession to Mr. W. Roberts who has retired.

MR. W. D. C. GOLDIE, A.M.I.Mech.E., has been appointed chief engineer and general manager of The National Boiler and General Insurance Company, Ltd., St. Mary's Parsonage, Manchester, 3. He succeeds Mr. W. F. Pearce, M.I.Mech.E., who is retiring at the end of April.

MR. J. P. CLIFTON, A.C.G.I., has been appointed manager of the contract department at the Witton works of The General Electric Company, Ltd., in succession to the late Mr. W. E. Evans. Mr. Clifton joined the company in 1935 as deputy manager of the contract department at Witton.

MR. E. A. HYDE has been appointed deputy managing director, and Mr. W. V. Hodgson, assistant managing director, of Wickman, Ltd., Tile Hill, Coventry. Mr. Hyde has been financial director since 1945, and Mr. Hodgson, who has been general manager of the machine tool division since 1949, was appointed to the board in 1953.

THE BOARD OF TRADE announces the appointment of Mr. J. W. Stoodley as trade commissioner and economic adviser to the High Commissioner in the Federation of Rhodesia and Nyasaland, in succession to Mr. H. W. Woodruff, who will complete his tour of service at the end of May. Mr. G. W. McNeil is to succeed Mr. Stoodley as trade commissioner in Pretoria.

THE NATIONAL COAL BOARD has announced some divisional and national appointments. Mr. R. W. Parker, at present deputy chairman of the N.W. division, is to be chairman of the Scottish division, in succession to Dr. W. Reid, who is now a member of the National Coal Board; Mr. L. Graham is to be chairman of the Northern (N. and C.) division in succession to Mr. J. Bowman, who is now deputy chairman of the National Coal Board. Mr. H. W. McQ. Hemby succeeds Mr. Graham as deputy chairman of the Northern (N. and C.) division, and Mr. A. W. John becomes director-general of finance at national headquarters in place of Mr. J. Latham, who is now a member of the National Coal Board.

Business Announcements

MR. F. D. ASCOLI, has retired from the managing directorship of Dunlop Plantations, Ltd.

HONEYWELL-BROWN, Ltd., has moved its Birmingham office to Sutton New Road, Erdington, Birmingham, 23.

MR. K. ZDZIARSKI, manager of the export sales division of Auto Diesels, Ltd., is touring South America.

EXPORT PACKING SERVICE, Ltd., has opened a new design and development department at Chipping Warden, Banbury.

MR. L. A. WOODHEAD, general manager of Cossor Instruments, Ltd., Highbury Grove, London, N.5, is visiting New York.

HARDINGE MACHINE TOOLS, Ltd., Feltham, Middlesex, has opened a new components depot at 18–19, Jennens Row, Birmingham, 4.

BURTON, GRIFFITHS AND CO., Ltd., states that its Leeds office has been moved to 8, York Place, Leeds, 1 (telephone, Leeds 34251). Mr. C. H. Viles is the branch manager.

MR. W. SCOTT, M.I.Mech.E., managing director of Armstrong Whitworth (Metal Industries), Ltd., and of Jarrow Metal Industries, Ltd., has left this country for an industrial tour in the U.S.A.

TWIFLEX COUPLINGS, Ltd., a subsidiary of Sheepbridge Engineering, Ltd., states that its sole selling agent for Scotland is now Charles Henderson and Co., Ltd., 73, Robertson Street, Glasgow, C.2.

DOWTY NUCLEONICS, Ltd., is the new title of the firm of Davis, Wynn and Andrews, which was recently acquired by the Dowty Group, Ltd., Cheltenham. Mr. G. H. Dowty is the chairman of the new company.

THE HOTPOINT ELECTRIC APPLIANCE COMPANY, Ltd., Perivale, Middlesex, has absorbed the businesses of International Refrigerator Company, Ltd., Peterborough, and Premier Electric Heaters, Ltd., Birmingham.

THE DOWSETT GROUP OF COMPANIES states that it is vacating the shipyard at Port Dinorwic, which it has operated since 1941. The group's shipbuilding activities are being transferred to the new shipyard which it has constructed at Lowestoft.

THE BRITISH ALUMINIUM COMPANY, Ltd., has acquired a majority interest in Magnesium Elektron, Ltd., hitherto a wholly owned subsidiary of the Distillers Company, Ltd. Major C. J. P. Ball continues as chairman of Magnesium Elektron, Ltd., and the British Aluminium Company, Ltd., has nominated the following as directors:—Hon. G. Cunliffe, Mr. W. J. Thomas, Mr. James Ritchie, and Dr. C. J. Smithells.

BABCOCK AND WILCOX, Ltd., announces the fusion of the trading activities of two of its subsidiaries, Spencer-Bonecourt, Ltd., and Clarkson Thimble Tube Boiler Company, Ltd. The resulting subsidiary company is entitled Spencer-Bonecourt-Clarkson, Ltd., the chairman of which is Captain (E.) W. Gregson, M.I.C.E. Mr. S. W. Spurr is managing director and Mr. A. E. Watkins is deputy managing director. The company's offices are at 14, Fetter Lane, London, E.C.4.

Contracts

POWER-GAS CANADA, Ltd., an associate of Rose, Downs and Thompson, Ltd., Hull, has received an order for a complete fish meal plant which is to be installed in the new processing works of Quebec United Fishermen, at Gaspé.

Miscellanea

METALWORKING PRODUCTION.—The McGraw-Hill Publishing Company, Ltd., 95, Farringdon Street, London, E.C.4, announces that as from April 15th the weekly magazine *The Machinist* will be published under the new title *Metalworking Production* (Incorporating *The Machinist*). Present features of *The Machinist* will be retained.

HEADS AND THREADS BUYERS' GUIDE, 1955.—The first edition of "Heads and Threads Buyers' Guide," which has just been published, lists the products of over a hundred firms concerned particularly with the manufacture of bolts, nuts, screws and rivets. The book is published at 5s., by the British Bolt, Nut, Screw and Rivet Federation, 69, Harborne Road, Edgbaston, Birmingham, 15. Details are also given of constituent Associations.

R.F. INDUCTION HEATING HANDBOOK.—A booklet on radio-frequency induction heating has been published by Radio Heaters, Ltd., Wokingham. Berks, to acquaint manufacturers with the advantages of induction heating, and illustrate some of its applications. For example, reference is made to the use of r.f. induction heaters in the production of semi-conductors: the zone refining of germanium, germanium crystal pulling and the manufacture of silicon crystals.

CONFERENCE ON FLUE DUST EMISSION.—The British Electricity Authority has published the proceedings of a national conference on "Flue Dust Emission," which was held at the headquarters of the South Wales Division of the B.E.A. on April 1-2, 1954. The proceedings opened with an address by the chairman, Mr. J. H. Bennett, after which nine papers were presented and discussed; the subjects included methods of dust and fuel sampling, dust emission troubles at Upper Boat, the grading of fly ash, dust collector performance in B.E.A. power stations, and the dispersion of chimney emissions.

STRENGTH OF COPPER TUBES AND CYLINDERS.—A new publication of the Copper Development Association is entitled "The Strength of Copper Tubes and Cylinders." In it are considered the effects of working conditions, references are made to recently published research work, and guidance is offered on design principles. It is hoped that by giving a better understanding of the relevant properties of the metal this booklet will lead to more efficient and more widespread uses of copper for pipe lines and cylinders. The booklet includes a bibliography, a list of British Standards and some alignment charts. It is available free on application to the association at Kendals Hall, Radlett, Herts.

COOLANT SUPPLY PIPES.—A new coolant feed pipe for machine tools, which is now being made by Creators, Ltd., Plansel Works, Sheerwater, Woking, Surrey, is sufficiently flexible to be bent easily but stays firmly in the set position. This pipe is known as the "Rigiflex," and is made of abrasion-proof synthetic material reinforced with a metal alloy to give rigidity. The material from which the pipe is made is resistant to petrol, oil, grease, water and practically all acids and alkalis. Each pipe is supplied complete with a nozzle-end and connection suitable for attachment to normal piping.

INSTITUTION OF MINING ENGINEERS' SUMMER MEETING.—The Institution of Mining Engineers is this year holding its summer meeting in Edinburgh on June 15th-17th. The papers to be presented at the meeting include "Physico Chemical Studies on Dust: Some Factors Controlling the Formation of Aqueous Sprays for the Control of Dusts; Some Factors Controlling the Rate of Sedimentation of Airborne Dusts," by Mr. W. Gibb, Mr. W. Glen, Professor G. Hibberd and Professor P. D. Ritchie; and "The Construction of New Collieries in Scotland," by Mr. H. R. King. Visits to neighbouring collieries and other places of interest and various social functions have also been arranged.

ENGINEERING WORKS CENTENARY.—We have received from Robert Dempster and Sons, Ltd., Rosemount Iron Works, Elland, Yorkshire, a brochure which the company has published to celebrate the centenary of its founding, and as a record of one hundred years of progress. The brochure contains a brief life history of the founder of the firm and reviews the development of the company, giving notes describing how and when various plant items were added to the company's products. There are representative views of the works, some of which are colour photographs of typical contracts, and the brochure includes an account of the works of to-day, together with data concerning the various departments.

FINISHING TOOL FOR WELDED LIGHT ALLOY SHEETS.—To provide a neat, clean finish on welded light alloy sheets, a method has been evolved by the Aluminium Development Association by using a modified 6in heavy-duty portable electric saw to remove the projecting beads from the sheets so that a flush surface is provided. The Black and Decker, Ltd., saw used was modified by mounting a milling cutter 2¼in diameter by ¼in wide on the blade shaft, and replacing the lower blade guard with an adjustable guide plate of teak or hard wood. The cutter speed used is between 2000ft to 3000ft per minute, and the guide plate is adjusted so that approximately 0·001in to 0·005in of metal is left upstanding for removal afterwards with a disc sander.

TWO-WAY CONTROL VALVE.—Dallow, Lambert and Co., Ltd., of Leicester, has recently introduced a modified two-way control valve for use in dust control systems. The new valve is made in a number of sizes to fit ducting from 4in to 22in diameter and can be used with all types of dusts, chippings, wood waste, &c. It consists of a "Y" piece containing a metal chute which can be pivoted to direct the flow as required. The flow path through the valve is smooth and the branch isolated by the chute is effectively sealed by a seating of durable flexible plastic. The spring loaded mechanism for operating the valve can be operated either by hand or remote control and is designed to give a rapid positive action which prevents the chute from taking up a position in which neither branch of the valve is sealed.

BIOLOGY AND CIVIL ENGINEERING.—A course of instruction entitled "Biology and Civil Engineering" is to be held in London on July 3–16, 1955. It has been planned by the British Council with the co-operation of the Institution of Civil Engineers, with the object of introducing civil engineers from overseas to some of the recent developments which have taken place in Britain in the application of biological research to engineering problems. The first week will be occupied mainly with problems related to water and sewage, such as bacteriological treatment of water, fresh-water molluscs, bacteriological corrosion of pipes, and sewage treatment and disposal. During the second week, attention will be given to problems related to construction, such as the preservation of timber against marine borers and also its preservation in structures, the effect of vegetation on structures, pest and weed control and stability of embankments. The course is open to overseas engineers actively concerned with biological and research problems connected with public works.

BRITISH RAILWAYS STANDARD COACHES.—British Railways have now introduced into service a number of standard passenger carriages without gangways or corridors. These carriages are designed in generally similar manner to the main line gangwayed stock, and have the same cross-sectional contour. Extensive use of welding is made in the assembly of the underframe, and of the pressed steel coach body pillars, roof members and outside panels. Although these particular designs may not be perpetuated under the British Railways modernisation plan, they will be equally suitable for haulage by diesel locomotives if necessary, and are assured of an economic working life. The new coaches have been specially designed for suburban services, and are of two lengths, 56ft 11in and 63ft 5in over the underframes, and 60ft 7in and 67ft 1in over buffers, respectively, and have side buffers and screw couplings. There are three types of body layout for each length of frame: third-class, third class brake and composite coaches. The third-class coaches carry 108 and 120 passengers, respectively; third-class brake coaches 72 and 84 passengers, with a combined guard's and luggage compartment; and the composite coaches 24 first and 72 third-class and 32 first and 72 third-class passengers.

British Patent Specifications

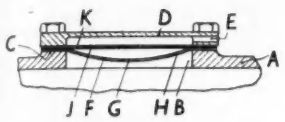
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

LUBRICATING SYSTEMS

725,023. April 27, 1953.—A VENTING AND OIL-RECOVERY DEVICE, Alfred Friedr. Flender, trading as A. Friedr. Flender and Co., 58, Kaiser Wilhelmstrasse, Bocholt, Westphalia, Germany.

In the drawing the device is shown mounted on a gear housing *A* with an opening *B* which is covered by a flat venting cover *D*. The vent cover has in one of its side edges venting slots *E*. Arranged between the frame *C* and the cover *D* at the lowest possible position is a concave oil-collecting dish *F* with a



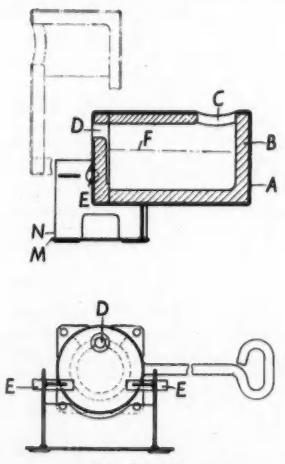
No. 725,023

central return opening *G* and a number of holes *H* at one side. A perforated screening plate *J* above the dish has holes *K* at the opposite side to the holes in the dish *F*. In operation rising oil vapour impinges on the convex underside of the oil-collecting dish *F* and passes through the apertures *H* towards the screening plate *J*, by which it is deflected to travel along the underside to the passages *K*. Most of the oil particles in the vapour are separated out and deposited in the collecting dish *F*, from whence the recovered oil flows back through the return opening *G* into the housing. The residual oil vapour passes through the openings *K* and the venting slot into atmosphere.—*March* 2, 1955.

METALLURGY

724,954. March 3, 1953.—LADLES FOR MOLTEN METAL, Sulzer Frères, Société Anonyme, Winterthur, Switzerland.

The invention relates to tilting ladles for molten metal castings, which reduces the risk of slag being carried into the moulds. The ladle as shown in the drawing consists of a cylindrical vessel comprising a casing *A* lined with a refractory *B*. A filling aperture *C* for pouring in the molten metal is disposed in the top of the ladle when the ladle is in the filling position, shown in full lines in the upper view. This aperture lies adjacent to the rear end wall. The pouring aperture *D* is located in the front end wall, which is removable. For this purpose it is provided with lugs which can be bolted to corresponding lugs on the body of the vessel. This removable wall facilitates the insertion of the refractory lining. The ladle is provided with a horizontal carrying handle which is perpendicular to the longitudinal axis of the vessel. Two trunnions *E* are welded on to the front end wall and form the axis about which the ladle can be tilted for pouring. The ladle is filled with molten metal when in the filling position, shown in the upper view, the metal being poured in up to about



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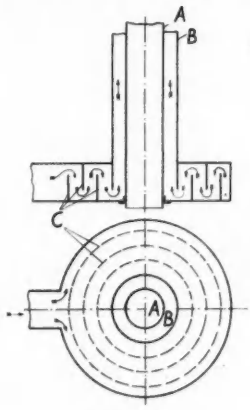
the level indicated by the chain dotted line *F*. The filled ladle is then carried to a tilting rest, which consists of a frame which can be mounted above the pouring gate of the mould. The two supports of the rest are each provided with a bearing slot which receives the trunnions *E* of the ladle. The pouring position of the ladle is shown in the upper view in broken lines. The level of the molten metal in the ladle when in the tilted position and before any appreciable amount has run out into the mould is indicated in the drawing by the chain dotted line, from which it will be apparent that any slag on the surface will be remote from the pouring aperture *D* and will not get carried into the mould. This slag is carried away by the residue of the metal which flows out of the ladle last.—*February* 23, 1955.

725,168. February 23, 1953.—CHILLING OF CONTINUOUS CASTING MOULDS, Gebr. Böhler and Co. Aktiengesellschaft, 12, Elisabethstrasse, Vienna 1, Austria.

As will be seen from the drawing, a mould *A* is shown surrounded by the cooling jacket *B*. Cooling agent is admitted to the mould in the neighbourhood of its exit orifice. Before the flowing cooling agent reaches the mould its direction of flow is repeatedly changed at right angles to the flowing direction by



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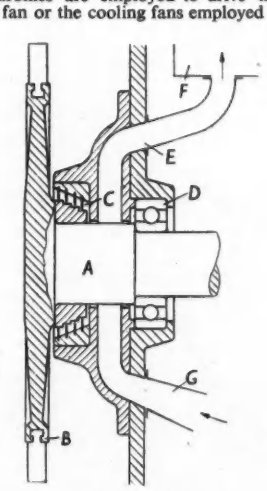
circular baffles *C*. In this way the tangential flow component produced as a result of admitting coolant through a single supply orifice against a cylindrical surface is removed. This continuous change of its direction of flow makes the coolant flow smoothly and after having been introduced into the cooling jacket *B* it is forced up in steady flow, without any circulating or whirling movement. The cooling liquid is removed as soon as it reaches the upper end of the mould, or flows down along the outside wall of the cooling jacket to enter the next mould, after having been deprived of its tangential flow component again by another set of baffles.—*March* 2, 1955.

RAILWAY ENGINEERING

725,311. February 17, 1953.—STEAM TURBINE SHAFT SEALING ARRANGEMENTS IN CONDENSING LOCOMOTIVES, Henschel and Sohn, G.m.b.H., 2, Henschelstrasse, Kassel, Germany.

In condensing locomotives one or more exhaust steam turbines are employed to drive the induced draught fan or the cooling fans employed in the con-



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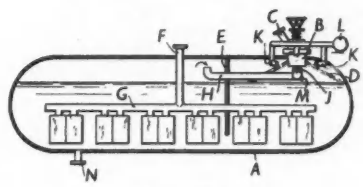
densing system and means has to be provided to prevent leakage to the shaft bearings of steam present at low super-atmospheric pressure in the turbine housings. As shown in the drawing, an annular chamber space around the shaft *A* of an induced draught turbine *B* accommodates a labyrinth shaft packing *C*. The chamber space is connected by way of passage *E* to the interior of a low-pressure space *F* which may be the smokebox of the locomotive or a cooling air shaft, in which space in working a negative pressure prevails. As a result, vapour leaking out from the labyrinth packing along the turbine shaft is sucked away so that the vapour is kept away from the shaft bearing *D*. The chamber space around the turbine shaft is connected to atmosphere by a tube *G* below the shaft. The specification also shows an injector device, the nozzle of which is operated by fresh steam when the turbine is idle, so as to suck away from the chamber space such vapour as may find its way through the labyrinth seal. The exhaust steam of the injector device is preferably conveyed into the condenser wherein these small quantities of steam will be condensed on the large cooling surfaces and will be recovered even when the cooling fans are stationary.—*March* 2, 1955.

STEAM GENERATORS

724,840. April 17, 1953.—APPARATUS FOR DEGASIFYING WATER, Koninklijke Machinefabriek Gebr. Stork and Co., N.V., of Hengelo (O.), The Netherlands.

The invention relates to an apparatus for removing gas from water, particularly boiler feed water. As will be seen from the drawing, in the top of the vessel *A* has at one of its ends a spraying device *B* to which



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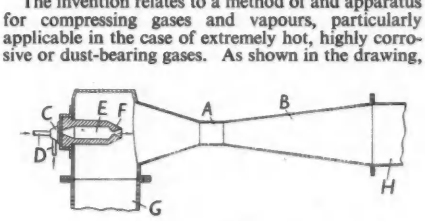
the boiler feed water to be degasified is supplied at *C* to be sprayed into the vessel in the form of a hollow cone *D*. The compartment, in which the water cone is formed, is separated from the remaining part of the vessel by an upright partition *E* extending below the water level. Steam is supplied to the vessel by a tube *F* from which a distributing conduit *G* is branched off. Above the water level in the vessel is a tube *H*, which at its one end is open and at its other end is provided with vertical outlet slots *J*, so that the steam and gases rising out of the water at the left-hand side of the partition *E* are discharged through the slots *J* below the water cone *D*, and pass through the water cone. For the withdrawal of the gases segmental pipes *K* (or a perforated annular tube) are located above the cone and connected to a common discharge conduit *L*. Tube *H* has an outlet *M* for the condensate. The vessel has an outlet *N* for the degasified water.—*February* 23, 1955.

BLOWERS AND COMPRESSORS

725,005. March 25, 1953.—EJECTORS FOR COMPRESSING GASES, Tor Fjalar Holmberg, Imatrankoski, Finland.

The invention relates to a method of and apparatus for compressing gases and vapours, particularly applicable in the case of extremely hot, highly corrosive or dust-bearing gases. As shown in the drawing,



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the apparatus consists of a venturi tube *A* and *B* through which the gas to be compressed is made to flow. Immediately in front of the inlet to the converging part of the venturi tube is arranged an ejector comprising a burner *C* into which air and gaseous fuel are conducted under pressure through the pipes *D* by a compressor pump of any suitable type. The combustion process is carried out under pressure and takes place in a combustion chamber *E*. After the combustion the gases are allowed to expand and flow with high speed through a nozzle *F* formed at the end of the chamber *E* nearest the venturi tube *A*, and strike against and mix with the gas to be compressed, which is admitted through an inlet pipe *G* into the venturi tube. After the mixing in the throat of the venturi the movement of the gas is retarded and converted into pressure energy. The gas thus compressed passes through a pipe *H*. An important feature of the invention is that the temperature in the combustion chamber shall be increased as high as possible, whereby the combustion gas flowing out through the nozzle of the combustion chamber receives a velocity appreciably greater than by known devices and consequently capability to an improved compression.—*March* 2, 1955.

Launches and Trial Trips

BELFAST, oil tanker; built at the Govan yard of Harland and Wolff, Ltd., for Belships Company, Ltd., Skibs A/S: length between perpendiculars 540ft, breadth moulded 73ft, depth moulded 39ft 3in, deadweight 18,500 tons; twenty-seven cargo oil tanks, two main cargo pump rooms, four 500 tons per hour cargo oil pumps; two 75kW steam-driven generators, one 75kW diesel-driven generator; two single-ended, three-furnace, multi-tubular boilers; one single-acting Harland and Wolff two-cycle, opposed-piston oil engine, six cylinders, 750mm diameter by 2000mm combined stroke. Trial, February 24th.

MOUNT EVEREST, trawler; built by John Lewis and Sons, Ltd., for the Seafield Fishing Company, Ltd.; length between perpendiculars 120ft, breadth 25ft, depth 12ft 6in, fish room 7000 cubic feet; Mirrlees "K.S.6" diesel engine, 650 b.h.p. at 250 r.p.m., trawl winch generator driven by a Mirrlees "T.L.A.6" diesel engine. Launch, February 24th.

NARUA, coaster; built by Henry Robb, Ltd., for the Union Steam Ship Company of New Zealand, Ltd.; length between perpendiculars 250ft, breadth moulded 41ft 6in, depth moulded to upper deck 17ft 9in, deadweight 2000 tons on 16ft mean draught, trial speed 11 knots; four cargo holds, ten 5-ton derricks, electric winches, three 114kW diesel-driven generators; one five-cylinder Clark-Sulzer two-stroke diesel engine, 1500 b.h.p. at 225 r.p.m. Launch, February 24th.

SHEAF HOLME, oil tanker; built by Joseph L. Thompson and Sons, Ltd., for the Sheaf Steam Shipping Company, Ltd.; length between perpendiculars 530ft, breadth moulded 71ft 10½in, depth moulded 40ft, deadweight 18,000 tons on 29ft 6in draught; eight centre and eighteen wing cargo oil tanks, two cargo pump rooms, service speed 15 knots; Doxford opposed-piston oil engine, six cylinders, 750mm diameter by 2500mm combined stroke, 7750 b.h.p. at 103 r.p.m. Launch, February 24th.

NOWSHERA, cargo liner; built by Scotts' Shipbuilding and Engineering Company, Ltd., for the British India Steam Navigation Company, Ltd.; length 514ft, breadth 67ft, depth to shelter deck 41ft 8in, draught 27ft 7⅛in, deadweight 10,250 tons; six holds, electric deck machinery, twenty derricks, also two heavy derricks of 25-ton and 50-ton capacity; trial speed 18 knots; one set of Parsons geared triple-expansion steam turbines, 10,250 s.h.p. at 116 r.p.m. of propeller, steam supplied at 475 lb per square inch and 750 deg. Fah. by two Babcock and Wilcox water-tube boilers. Trial, February 25th.

PORT SYDNEY, refrigerated cargo ship; built by Swan, Hunter and Wigham Richardson, Ltd., for the Port Line, Ltd.; length between perpendiculars 498ft, breadth moulded 70ft, depth moulded 42ft 0½in, load draught 28ft 9½in, deadweight 11,120 tons, gross tonnage 9992 tons; service speed 17 knots; insulated cargo 334,500 cubic feet, uninsulated cargo 295,800 cubic feet; three steel decks, six holds, complement of derricks to lift 10 tons and 15 tons and one to lift 70 tons, electric winches; four 300kW diesel-driven generators; two Wallsend-Doxford single-acting, two-stroke oil engines, six cylinders, 670mm diameter by 2320mm combined stroke, total power 13,200 b.h.p. at 112/113 r.p.m. Trial February 28th.

VESTVARD, oil tanker; built by Smith's Dock Company, Ltd., for Klosters Rederi A/S; length overall 555ft 9in, length between perpendiculars 530ft, breadth moulded 71ft, depth moulded 39ft, deadweight 18,178 tons on 29ft 8½in draught, loaded trial speed 15·6 knots; twenty-seven main cargo oil tanks, two main pump rooms, four 500 tons per hour cargo oil pumps, steam deck machinery; three 50kW generators, two steam-driven and one diesel-driven, two Scotch oil-fired boilers; one Kincaid-Harland and Wolff two-stroke, single-acting, opposed-piston diesel engine, seven cylinders of 750mm diameter by 2000 combined stroke, 7500 b.h.p. at 110 r.p.m. Trial, February.

POLARPRINS, oil tanker; built by Barclay, Curle and Co., Ltd., for Hvalfangerselskapet Polaris A/S, Norway; length 557ft, breadth 73ft 9in, depth 40ft, deadweight 18,300 tons; twenty-seven cargo oil tanks, two cargo pump rooms, four cargo oil pumps, one stripping pump, Butterworth tank cleaning system; two multi-tubular composite cylindrical boilers, Barclay, Curle-Doxford oil engine, six cylinders, 750mm diameter by 2500mm combined stroke, Doxford-Bibby detuner. Trial, March 4th.

WORLD GRANDEUR, oil tanker; built by Howaldtswerke Hamburg A.G., for Niarchos (London), Ltd.; length overall 700ft, length between perpendiculars 663ft, breadth moulded 97ft 5in, depth moulded 47ft 5in, summer draught 35ft 3¼in, deadweight 38,500 tons; thirty-three cargo oil compartments, one cargo oil pump room, five 1000 tons per hour turbine-driven centrifugal cargo pumps; speed 17 knots; two 600kW turbine-driven alternators, one 130kW diesel-driven alternator; one set of double-reduction geared turbines, maximum power 17,000 s.h.p. at 110 r.p.m., and normal power 16,000 s.h.p. at 107 r.p.m. of propeller, propeller four blades, 22·6ft diameter by 14·1ft pitch, steam supplied at 600 lb per square inch and 830 deg. Fah. by two Foster Wheeler "D" pattern oil-fired boilers. Launch, March 4th.

PRINCESS OF VANCOUVER, passenger, train and car ferry, built by Alexander Stephen and Sons, Ltd., for the Canadian Pacific Railway; length overall 416ft, length between perpendiculars 388ft, breadth moulded 63ft, breadth over fenders 66ft, depth moulded 19ft 6in, four railway tracks, 28 rail box cars or 115 motor-cars, deadweight 2300 long tons, 7000 tons gross, service speed 15½ knots; 800 passengers; electrically driven bow propeller, four National pressure-charged, seven-cylinder diesel engines, each 1575 b.h.p. at 333 r.p.m., each pair of engines drives a propeller shaft at 200 r.p.m. through "Fluidrive" hydraulic couplings and a Hindmarch/MWD oil-operated reverse reduction gear. Launch, March 7th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., April 13th.—LONDON SECTION: School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Discussion Meeting on "The B.B.C., V.H.F., F.M. Sound Broadcasting Service," opened by K. R. Sturley and F. T. Lett, 6.30 p.m.——N.E. SECTION: Neville Hall, Westgate Road, Newcastle upon Tyne, "The Manchester University Electronic Computer." E. T. Warburton, followed by the Annual General Meeting, 6 p.m.

Thurs., April 14th.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Film Evening and Exhibition of Electronics Apparatus, 7 p.m.

ELECTRIC RAILWAY SOCIETY

Sat., April 2nd.—Visit to London Transport Railway Training Centre, starting from Lambeth North Station Booking Hall, 2.10 p.m.

ENGINEERS GUILD

Thurs., April 14th.—Caxton Hall, Caxton Street, Westminster, London, S.W.1, "Interplanetary Travel," G. S. Brosan, 6 p.m.

ILLUMINATING ENGINEERING SOCIETY

Wed., April 6th.—EDINBURGH CENTRE: Manor Club, 12, Rothesay Place, Edinburgh, Annual General Meeting and Films, 7 p.m.——NEWCASTLE CENTRE: Liberal Club, Pilgrim Street, Newcastle, Annual General Meeting, 6.15 p.m.——SWANSEA GROUP: S. Wales Electricity Board's Demonstration Theatre, The Kingsway, Swansea, "Black Light—its Effect and Applications," H. L. Privett, 6.30 p.m.

Thurs., April 7th.—CARDIFF CENTRE: S. Wales Electricity Board's Demonstration Theatre The Hayes, Cardiff, "Black Light—its Effect and Applications," H. L. Privett, 5.45 p.m.——NOTTINGHAM CENTRE: E. Midlands Electricity Board, Smithy Row, Nottingham, "Compromise in Lighting Fittings Design," J. Studholme, 6 p.m.

INCORPORATED PLANT ENGINEERS

Tues., April 5th.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "The Application of Gas Turbines to Industrial Duties," G. B. R. Feilden, 6.30 p.m.

Wed., April 6th.—LEICESTER BRANCH: College of Art and Technology, The Newarkes, Leicester, "Use of Electrical Equipment in the Hosiery Industry," E. W. Freeman, 6.30 p.m.——SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, Brains Trust, 7.30 p.m.

Thurs., April 7th.—PETERBOROUGH BRANCH: Campbell Hotel, Bridge Street, Peterborough, "Lubrication" 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

To-day, April 1st.—TEES-SIDE BRANCH: Teesdale Hall, Head, Wrightson and Co., Ltd., Thornaby-on-Tees, Annual General Meeting, Presentation of Awards, Apprentice Competition, followed by "Any Questions," 7.30 p.m.

Sat., April 2nd.—NEWCASTLE BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, Annual General Meeting, "Exothermic Feeding Heads," W. Stewart, 6 p.m.——E. MIDLANDS BRANCH: College of Arts, Derby, Annual General Meeting, followed by Short Paper Competition, 6 p.m.

INSTITUTE OF FUEL

To-day, April 1st.—S. WALES SECTION: S. Wales Institute of Engineers, Park Place, Cardiff, "Start of the National Industrial Fuel Efficiency Service," W. A. Macfarlane, 6 p.m.

Mon., April 11th.—N.E. SECTION: Chemistry Lecture Theatre, King's College, Newcastle upon Tyne, Lecture by the President, W. Idris Jones, 6.30 p.m.

INSTITUTE OF METALS

To-day, April 1st.—SPRING MEETING: Visits for Members and Male Guests.

Thurs., April 7th.—BIRMINGHAM LOCAL SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, 6.30 p.m.

INSTITUTE OF PETROLEUM

Wed., April 13th.—Manson House, 26, Portland Place, London, W.1, "Refining Methods for Maximising Middle Distillate Production," L. S. Bonnell, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., April 4th.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, "Roads and Commercial Transport," G. Charlesworth, 7.30 p.m.

Wed., April 6th.—E. MIDLANDS CENTRE: Mechanics Institute, Nottingham, "Gas Turbines and their Application to Road Transport," A. Enticknap, 7.30 p.m.

INSTITUTE OF WELDING

Tues., April 5th.—E. MIDLANDS BRANCH: Victoria Station Hotel, Nottingham, Annual General Meeting and Film Show, 7.15 p.m.

Wed., April 6th.—EAST OF SCOTLAND BRANCH: Ramsey Technical College, Portobello, Annual General Meeting and Demonstration Night, 7 p.m.——MANCHESTER BRANCH: College of Technology, Manchester, Annual General Meeting and Films, 7.15 p.m.——S. LONDON MEDWAY SECTION: Sun Hotel, Chatham, Annual General Meeting, 7.45 p.m.

Thurs., April 7th.—N.E. (TEES-SIDE) BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, Annual General Meeting and Films, 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., April 5th.—HYDRAULICS MEETING: Great George Street, Westminster, London, S.W.1, "Some Hydraulic Aspects of Sewerage and Sewage Disposal," C. B. Townend and G. W. Wilkinson, 5.30 p.m.

Thurs., April 14th.—N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, "Present Situation on Retaining Wall Design," P. W. Rowe, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., April 4th.—S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Automatic Circuit Reclosers," G. F. Peirson, A. H. Pollard and N. Care, 6 p.m.

Tues., April 5th.—MEASUREMENTS AND RADIO SECTIONS: Savoy Place, London, W.C.2, "High Speed Electronic Analogue Computing Techniques," D. M. Mackay, 5.30 p.m.——N. MIDLAND CENTRE: Royal Station Hotel, York, "The Possibilities of a Cross Channel Power Link Between the British and French Supply Systems," D. P. Sayers, M. E. Laborde and F. J. Lane, 7 p.m.——S.E. SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "The Electrification of the Manchester-Sheffield-Wath Lines," J. A. Broughall and K. J. Cook, 7 p.m.

Thurs., April 14th.—UTILIZATION SECTION: Savoy Place, London, W.C.2, "The Installation of Metal-Sheathed Cables on Spaced Supports," W. Holttum, 5.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Thurs., April 7th.—Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "Diesel Engines and Aeronautics," Film Show, 7.15 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, April 1st.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, Discussion upon the Currently Proposed Road Programme; Speakers C. T. Brunner ("The Economic and Financial Angle"), A. C. Newman ("The Constructional Angle"), and Sir E. Owen Williams ("The Design Angle"), 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, April 1st.—GENERAL MEETING, APPLIED MECHANICS' GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "An Electrolytic Tank Investigation into Stepped Thrust Bearings," C. F. Kettleborough; "Journal Bearing Performance under Sinusoidally Alternating and Fluctuating Loads," G. S. A. Shawki and B. Freeman; "Bending Stresses in Spur Gear Teeth: Proposed New Design Factors Based on a Photo-Elastic Investigation," M. A. Jacobson; "Prediction and Measurement of Vibration in Marine Geared Shaft Systems," by the late H. G. Yates; "The Promotion of Fluid Lubrication in Wire Drawing," D. G. Christopherson and H. Naylor; "Experimental Investigation of the Mechanics of Wire Drawing," J. G. Wistreich, 2 p.m.

Mon., April 4th.—E. MIDLANDS GRADUATES' SECTION: Gas Showrooms, Nottingham, Annual General Meeting and Films, 7.30 p.m.

Tues., April 5th.—AUTOMOBILE DIVISION GENERAL MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, Three Papers on Small Four-Stroke Diesel Engines, "Matching a Diesel to Light Road Vehicles," N. Vulliamy; "Some Aspects of the Design and Performance of Small Diesel Engines," B. W. Millington and M. H. Howarth; "Fuel Requirements of the Small Automotive High-speed Diesel Engine," G. M. Barrett and H. G. Freeston, 5.30 p.m.

Wed., April 6th.—HYDRAULIC GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion, 6.45 p.m.

Fri., April 15th.—GENERAL MEETING, INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Surface Examination by Reflection Electron Microscopy," J. S. Halliday, 5.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Mon. to Wed., April 4th to 6th.—SPRING MEETING, 1955: Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1: *Monday:* Opening of Weir Lecture Hall by the President, Viscount Runciman of Doxford, 5.15 p.m.; The Amos Ayre Lecture, "The Man and His Work," a lecture prepared by the late Sir Maurice E. Denny, Bt., 5.30 p.m.; *Tuesday:* "B.S.R.A. Resistance Experiments on the 'Lucy Ashton,' Part IV, Miscellaneous Investigations and General Appraisal," S. Livingston Smith, "Recent Developments in Naval Life-Saving Equipment," W. J. Holt, 10.15 a.m.; "A Hundred Years of Lloyd's Register Ship Rules," J. M. Murray, "Forty Years of Change at Portsmouth Dockyard," with Some Notes on Dockyard Organisation," I. E. King, 2.15 p.m.; tea interval, 4.15 p.m.; Joint Paper with The Institute of Marine Engineers, "Sea Trials on a 9500 D.W. Motor Cargo Liner," G. Aertssen, 5.0 p.m.; *Wednesday:* Annual General Meeting, "Liners of the Past, Present and Future on Service East of Suez," Sir William C. Currie, 10.15 a.m.; "The Cathodic Protection of Ships Against Sea-Water Corrosion," L. T. Carter and J. T. Crennell, 2.15 p.m.; dinner at Connaught Rooms, 7.0 for 7.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Wed., April 6th.—ORDINARY MEETING: Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Regional Problems in the Provision and Maintenance of V.H.F., U.H.F. and S.H.F. Radio Links," F. Moxon, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Tues., April 5th.—LIVERPOOL GRADUATE SECTION: Stork Hotel, Liverpool, "Planning on Archæological Excavation," J. H. Iliffe, 7.45 p.m.——LONDON GRADUATE SECTION: 10, Chesterfield Street, London, W.1, Annual General Meeting and Film Evening, 7.15 p.m.

Wed., April 6th.—HALIFAX SECTION: Collinson's Cafe, Crown Street, Halifax, "The Production of Modern Electric Washing Machines," J. Senior, 7.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., April 4th.—N.E. SECTION: Mining Institute, Neville Street, Newcastle upon Tyne, Annual General Meeting, 7 p.m.——BURTON-ON-TRENT SECTION: Midland Hotel, Station Street, Burton-on-Trent, Annual General Meeting and Film Evening, 7.15 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, April 1st.—FILM EVENING: Pepys House, 14, Rochester Row, London, S.W.1, "The Miner," "Plan for Coal," "The Scraper Box" and "Coalmining To-day," introduced by Lambton Wilkinson, 7 p.m.

Tues., April 5th.—SHEFFIELD AND DISTRICT SECTION: Royal Victoria Hotel, Sheffield, Visit of Officials from Headquarters, Presidential Address, "Engineering in the Twentieth Century," S. J. Davies, 7.30 p.m.

Wed., April 6th.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Combined Meeting with the Newcomen Society, "Machine Tools—Historical Development—Future Trends," 7 p.m.

LONDON ASSOCIATION OF ENGINEERS

Sat., April 2nd.—Alliance Hall, Palmer Street, London, S.W.1, "Overall Picture of the N.P.L., Teddington," J. Garrett, 6.30 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Mon., April 4th.—Mining Institute, Newcastle upon Tyne, "Some Investigations into Singing Propellers," S. G. Lankester and W. D. Wallace, 6.15 p.m.

NORTH WESTERN FUEL LUNCHEON CLUB

Wed., April 6th.—Engineers' Club, Albert Square, Manchester, "Britain's Energy Needs," Donald Hicks, 12.45 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., April 4th.—ORDINARY GENERAL MEETING: 12, Great George Street, Westminster, London, S.W.1, "Why Put Your Money in Land?" W. M. Balch, 5.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

To-day, April 1st.—CORROSION GROUP: Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Symposium on "The Protection of Structural Steel": "Exposure Tests of Paints and Zinc Coatings in Sweden," K. F. Tragardh and P. Nylen; "The Formulation of Priming Paints for Structural Steel," J. C. Hudson and J. F. Stanners; "Results of Researches of the Belgian Corrosion Committee," M. van Rysselberge and D. Bermane, 9.30 a.m. to 1.0 p.m.; "Practical Experience with Sprayed Metal Coatings," W. E. Ballard and F. A. Rivett; "The Use and Weldability of Aluminium-Sprayed Steel," H. F. Tremlett and W. A. Johnson; "Protection Problems in Chemical Factories," F. R. Himsworth, 2.30 p.m. to 5.0 p.m.

SOCIETY OF INDUSTRIAL ENGINEERS

To-day, April 1st.—Management House, 8, Hill Street, London, W.1, "What Industry Expects of Education," Cecil Potter, 7 p.m.

Sat., April 2nd.—The Building Centre, 425, Sauchiehall Street, Glasgow, "The Trade Union View on Work Study," 10 a.m.